Coping with Digitalization in Operations Processes: The Role of Design Thinking

Luca Vendraminelli (luca.vendraminelli@phd.unipd.it)
Università di Padova, Italy

Laura Macchion (laura.macchion@unipd.it)
Università di Padova, Italy

Anna Nosella (anna.nosella@unipd.it)
Università di Padova, Italy

Andrea Vinelli (andrea.vinelli@unipd.it)
Università di Padova, Italy

Abstract

Based on an in-depth literature review of Design Thinking and Industry 4.0 concepts, we develop a methodology that supports companies in handling and defining a set of digital priorities and objectives aligned with their corporate business strategy and in deploying it into operative plans. This way companies are able to enhance the effectiveness of digital investments and select and exploit the most prominent and strategic ones for their business.

A test of the advanced method is furthermore conducted in a sample of five non-competitive companies with the rationale of collecting empirical data on the ground to understand potentialities as well as limits of the proposed method.

Introduction

Nowadays market shares, profitability and efficiency are at stake because technology advancements have brought companies into the fourth industrial revolution, also named Industry 4.0, that has been deeply mutating the way companies produce value and what value is for clients. The Boston Consulting Group (2015) has identified nine groups of technologies enabling Industry 4.0 (Rüßmann, et al., 2015). These clusters of technologies , through the digitalization of business, are reshaping companies' strategy (Bhradwaj, et al., 2013), organization (Snow, et al., 2017), products and services (Porter & Heppelmann, 2015), supply chains and operations processes (Zuehlke, 2010; Lee, et al., 2015). Thus, introducing this kind of technologies to engage digitalization is an extant priority for many companies, but this change process needs to be steered and nurtured. Many governments (e.g. United States, Germany, France, United Kingdom, South Korea, China, Japan, Singapore) have drawn up tax reductions plans for increasing the appeal of digital investments and favoring companies' digitalization path.

Within this move, firm's IT strategy has been shifted from functional to business level, and companies are facing the need to determine their Digital Business Strategy (DBS) to tackle and take full advantage of Industry 4.0. DBS is defined as "the organizational strategy formulated and executed by leveraging digital resources to create differential values" (Bhradwaj, et al., 2013). At best of our knowledge, methodologies that support companies in approaching and defining their DBS are scant, while the opportunities offered by the Industry 4.0 scenario are vast and huge.

The aim of this paper is to present and test a methodology based on Design Thinking (DT) (Kimbell, 2011) to support companies in defining company's Digital Business Strategy. DT is the set of best practices, cognitive styles and mindsets (Hassi & Miko, 2011) that designers adopt to create newness (Buchanan, 1992; Boland & Collopy, 2004). The concept is endorsed in the management discourse, referring to how companies can make use of designer's way of working.

Theoretical Background

The concept of Industry 4.0 was initially introduced in Germany in 2011 (Sanders, et al., 2016; Lu, 2017) referring to the integration of physical objects, human actors, intelligent machines, production lines and processes across organizational boundaries, with the aim of realizing a system in which all the processes are integrated and information is shared in real time (Hozdić, 2015). Industry 4.0 matches with the fourth industrial revolution. The First was sparked by the mechanization of the human physical power trough James Watt's steam engine, invented in 1781; the Second by the electrification and mass production between 1870s and 1900s; and the Third by the unleashing of computing power and automation in the late 20th Century. As in the past, even the fourth industrial revolution has been catalyzed by the technology advancements. These technologies, clustered by The Boston Consulting Group (2015) in nine different groups, are: Autonomous Robot, Simulation, Horizontal & Vertical System Integration, The Industrial Internet of Things, Cybersecurity, The Cloud, Additive manufacturing, Augmented reality, Big data & Analytics.

From the standpoint of a company, harnessing the potential of Industry 4.0 is a challenging task since it involves and calls for selecting first, and exploiting then, the most prominent and strategic digital investments, among the many offered by the nine clusters of technologies, for achieving the best improvement in company's performances. In a nutshell, we could maintain that a company, to fully exploit the potential of Industry 4.0, needs to determine its own Digital Business Strategy (DBS) defined as "the organizational strategy formulated and executed by leveraging digital resources to create differential values" (Bhradwaj, et al., 2013).

Why defining a Digital Business Strategy is a wicked problem

A Business Strategy is a framework for actions that has to guide people in decision-making processes, to help them prioritizing activities and allocating resources on what is relevant for the corporate success (Watkins, 2007; Camillus, 2008). The increased relevance and impact of the abovementioned nine groups of technologies have given rise to the concept of DBS, a new cross-functional concept of strategy representative of the growing importance of digital resources (Bhradwaj, et al., 2013; Bertelè, 2016). Literature has shown that the strategic planning itself - and in particular the DBS planning – can be defined as a wicked problem, because of the stakeholders' differences in values and priorities, the tangled root causes, the uniqueness of problems to deal with, and the hurdle of not being able to estimate the quality of the outcome (Camillus, 2008).

In the *Dilemmas in a General Theory of Planning*, authored in 1973, Rittle & Webber introduced for the first time the locution wicked problem. They identified ten characteristics that distinguish wicked from tame problems, which have the proprieties of being perfectly definable and leading to a solution that is findable – as hard the task might be. In contrast to tame problems, wicked problems are ill-defined, and the final solution depends on the subjective judgement of the problem solver. For a company, coping with its DBS is a wicked problem since it involves analyzing many different

opportunities offered by the technology advancements of Industry 4.0 without knowing if the outcomes are the best possible result (i.e. wicked problems have no stopping rules and solutions to wicked problems are not true-or-false, but good-or-bad (Rittle & Webber, 1973)). Defining a DBS is also a wicked problem because of its uniqueness within every company, and this makes impossible to learn by trial and error. Moreover, implementing plans are frequently very expansive.

In this scenario, management techniques, analytical tools and quantitative methods, well suited for reliable situations and for a rationally choosing of the optimum among a set of alternatives, seem to be ill-suited for operating (Boland & Collopy, 2004; Liedtka & Ogilvie, 2011).

All in all, Industry 4.0 is challenging companies in coping with the wicked problem of planning a Digital Business Strategy, but how can this be accomplished? Literature on Design Thinking (DT) can help in this task. Designers are used to solve wicked problems and DT is the subject matter that depicts how to do it. (Boland & Collopy, 2004; Buchanan, 1992; Johansson-Sköldberg, et al., 2013). Richard Buchanan's Wicked Problems in Design Thinking (1992) provides a proof of the bond beyond design and wicked problems.

In the last decade a stream of research that considers DT as an organizational resource for companies has arisen (Kimbell, 2011). In this vision, DT is about empathizing with the environment in which the problem lies (e.g. stakeholders, constraints), imagining future scenarios rather than accepting the extant situation, adopting iteration and a divergent-convergent approach to problem solving, and using prototyping and visualization methods to make ideas tangible and manage connections and complexity (Brown, 2009; Liedtka & Ogilvie, 2011).

Many authors have presented methods that aim to organize the innovation activities flows using DT approach (e.g. Martin, 2009; Liedtka & Ogilvie, 2011; Brown, 2009; Knapp, et al., 2016). The most famous one is the five-stage process built by the d.school Institute of Design at Stanford in collaboration with Tim Brown's IDEO (d.school Institute of Design, 2010). In the specific case, the innovation development process has been divided into five different stages: empathize with the problem to face, define which is the challenge that has to be tackled, ideation, prototyping and test of the solution.

All these methods may be a starting point for developing a methodology that allows companies to manage the design of a proper digital transformation, crafting their DBS in a way that unleashes the power of technology to improve their performances.

Methodology of the research

In recent years Industry 4.0 has made a large turmoil in the industrial and academic society, witnessed by the growing number of publications, articles, consulting reports and conferences on the theme (Johansson-Sköldberg, et al., 2013). The acknowledgement of Industry 4.0 pivotal role in the future of industries and society led us to launch this research project, with the intention to forge a method that could help companies to handle the complexity of digital transformations.

The research project started in January 2017 lasted one entire year and it has been divided into two separate phases: the development of the method and the test. The research team was made by the authors with the assistance of a consulting firm throughout all the project lifetime. It helped both contributing in the refining of the method and supporting the testing phase deploying resources on the ground.

Between January and July 2017, the research team has worked on the construction of the method proposed in this paper. Initially, a deep literature review on Design Thinking

and Industry 4.0 was conducted by examining books, journals, electronic databases and also informal tools as search engines and blogs.

The results of the literature review process allowed us to define the theoretical framework upon which the team has built the method using DT practices. At a later stage indeed, with the help of structured brainstorming sessions with convergent-divergent approach (Brown, 2009, pp. 77-79), we sketched a map of all the footsteps we thought a company had to follow to define its DBS (i.e. how digital resources might be useful to corporate success (Bhradwaj, et al., 2013)).

When we came up with the first prototype after months of iterative work, we kicked off a refining process interviewing a panel of managers. In July 2017, finally, the method was ready to be tested in a sample of companies with the purpose of collecting feedbacks on the ground.

The proposed method

The method we propose (Figure 1) makes a group of five non-competitive companies working together in tackling the DBS definition issues. In turn, each of the five companies (i.e. the focal firm) first defines its DBS priorities and then works with the other four companies to set operative plans to deploy the identified DBS challenges.

In particular, the method comprises two different phases: The Challenge Definition and The Opportunity Exploration.

The Challenge Definition

The Challenge Definition phase is conducted by the top managers of the focal firm for defining the company's DBS. The objectives are strictly matter of strategy, and this is the reason why companies are advised to involve into this phase the top management.

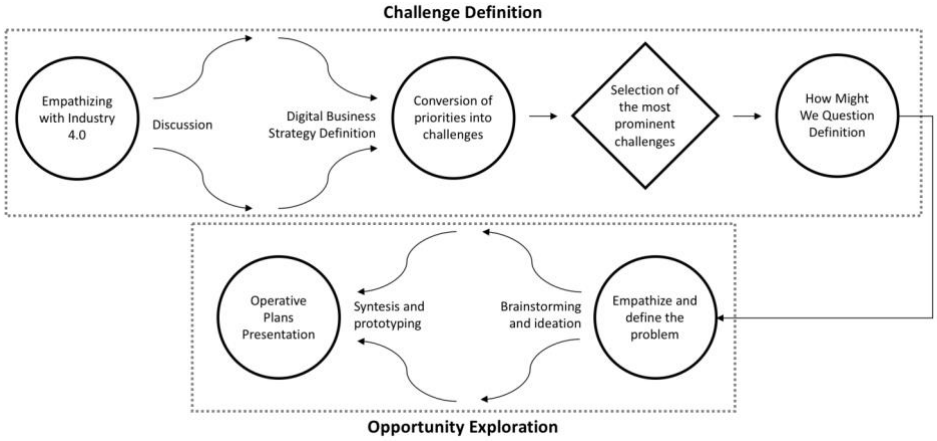

Figure 1: The proposed method

This phase lasts several days and activities encompass: (1) empathizing with the concept of Industry 4.0 by aligning managers' views on the topic, (2) assessing the ongoing business strategy to choose a "working perimeter" and to create the most relevant digital challenges for each area, (3) evaluating, prioritizing and selecting two overriding Challenges, and (4) defining the "how might we…?" questions for every identified Challenge. In particular:

1) *Empathize with Industry 4.0:* at the beginning managers of the focal firm are required to empathize with the concept of Industry 4.0 (i.e. align themselves on what Industry 4.0 does mean). In our experience, we have noticed that managers used to have a narrow view of the Industry 4.0 phenomenon, often confined on their own routines. This had to be overtaken. In this regard, the exchange of

opinions proved to be a useful activity: we have asked managers to write a short definition of Industry 4.0 down into a post-it, to stick it on the wall, and then, working in team, to merge all the definitions into a new one that was representative of all the instances. Depending on the digital skills level of the team selected, one may also plan workshop, seminars or lectures to build confidence on technology.

2) *Assessment of the ongoing business strategy and definition of the most relevant digital challenges:* after managers have mapped the company's business strategy, they have to brainstorm on which kind of digital transformations should be done to make the best use of the available advancement in technologies. Due to the fact that "*without rules there is no framework for a group to collaborate within, and a brainstorming session is more likely to degenerate* […]" (Brown, 2009, p. 78), we have defined some guidelines borrowing the following IDEO's rules: defer judgment, encourage wild ideas, stay focused on the topic, build on the ideas of others, one conversation at time, be visual, go for quantity. In a successive convergent phase, the team must synthetize every proposal in a A4 paper using sentences, symbols, maps or drawings. The outcome is the first rough proposition of a digital challenge, defined as the need for an investigation to design a digital and strategic improvement.
3) *Selection of the challenges:* After the challenges have been created, we have set a gate to reduce them in number for not squandering the commitment, because resources on the companies' tables are always limited. Thus, managers are required to use management tools (e.g. the SWOT analysis, pros and cons analysis) to gather all the insights needed to select the two challenges to invest on. We have recommended the standard of two challenges for ensuring to be able to effectively manage the subsequent phase, but this is not a binding constraint.
4) *Definition of the input for the Opportunity Exploration phase:* finally, once the two challenges have been selected, a formal issue that must be resolved still remains. The challenges need to be easy to communicate, so managers are asked to rephrase them complying with the How Might We Question Model by Stanford d.school & IDEO; thence, the challenge (a) must be a question and b) must clarify who is the user, which are the insights, and what is the target to be achieved.

The Opportunity Exploration

The Opportunity Exploration phase lasts one week for each company; it takes place at the focal firm which hosts the employees of the other four companies that collaborate with the focal firm with the aim of investigating a way to resolve the challenges set out by the managerial team of the focal company. Five employees, belonging to different functional areas of each company, participate in Opportunity Exploration phase. Out of the 25 people, five intercompany operative teams are created (Figure 2). The five teams involve one employee for each company participating in the project (i.e. if there are 5 companies participating, teams will consist of 5 people), and every challenge is assigned at least to two different teams with the aim of showing potential differences due to diverse group dynamics. The management of the focal firm, scouting the curricula of the employees, decides deliberately to assign one selected challenge to two group and the other one to the remaining three groups (Figure 2).

The Exploration phase lasts five full days within one entire week and includes: (5) empathizing with the "How might we…?" questions, as outcome of the previous step, and defining the problem to solve and the constraints to adjust to, (6) brainstorming to harvest the largest number of ideas and selecting and prototyping the finest ones, and (7) reporting the outcome to the focal company top managers.

5) *Empathizing with the nature of challenge and defining the problem that has to be solved:* at first, each team must choose one of the two challenges presented by the corporate team which took part to the former phase. Empathizing with the nature of the challenge means to acquire knowledge about the challenge's theme. Teams have the possibility to organize their schedule at will, but they have to report to the management team a timeline of the weekly plan they intend to follow at the end of the first day.
6) *Brainstorming and selecting the finest ideas:* at this point, the operative teams should have a deep awareness of the problem they are dealing with, so they are ready for an iterative divergence-convergence process of innovation. The first step, divergence, is about creating ideas with the use of the brainstorming techniques that managers have used in (2). Convergence, on the contrary, is about making a choice, filtering the results with qualitative and quantitative methods. The process is iterative, because it is repeated until the teams believe it is worthwhile to improve the quality of the outcome.
7) *Report creation and presentation:* the last activity is the recap of the outcome on the work in the form of a presentation. This request forces the operative teams to prototype the solutions found in an easy-to-communicate way, by cutting corners and simplifying procedures. Finally, to reinforce the commitment of the teams, a reward is usually reserved for the best presentation, according to the top management of the focal firm.

The test of the method: results

In September 2017 the test started with a sample of five different manufacturing and non-competitive companies. The number of the companies in the sample was selected to balance the size of the teams in the opportunity exploration phase; in particular for each company five people were involved, with a total of 25 employees, as previously described. The selected firms were at an early stage in the approach to digital transformation, but all showed a need and a will for exploring digital opportunities. They belong to different sectors (i.e. electronics, energy and machinery), they have different sizes (revenues range from €50 to €500 millions) and value propositions, and they show a high level of world-class operational and organizational practices. Table 1 summarizes the profiles of the companies participating in the testing phase.

Eventually, the method has been tested five times in a row, every time led by one different company in the role of the focal firm that has conducted the Challenge Definition phase, defining its Digital Business Strategy, and hosted intercompany teams in the Opportunity Exploration phase, where all the companies taking part in the project had to support the process of deploying priorities into concrete operative plans.

The research team actively managed and drove both the Challenge Definition and Opportunity Exploration phases. This active participation along all the activities of the project test allowed us to get hold of a rich data set of documents, noted observations and unstructured interviews made alongside the whole project to managers and employees of the companies.

All the data collected during the test of the proposed method are summarized in Table 2. It shows the outcomes of the Challenge Definition phase that each firm has

produced in the role of the focal firm, and of the operative plan created by the intercompany team that was rewarded in the Opportunity Exploration phases.

Findings

In light of the results of the analysis made on the data collected in the test phase, we propose some findings to spark discussion and future research.

Two different use of Design Thinking

All the companies participating in the project have formalized and prototype their DBS by creating objectives and priorities and then by converting priorities into challenges. Yet, two different categories of challenges emerged. The first category is composed by the challenges (1, 3, 4, 9, 10 of Table 2) that took advantage of Design Thinking to replace ineffective innovation process. For instance, in the development of connected-products or of new services for clients based on analytics. This usage adheres rigorously to the works on DT made by Tim Brown (2009) and IDEO with the d.school of design. In the interviews made during the projects, it was clear that most of the innovation managers were unsatisfied of their company's innovation rate (i.e. number of product developed per year), and consequently they were happy to adopt DT practices for by-passing the ordinary standards of product development, creating a new and effective flow of innovation.

The other category of challenges (2, 5, 6, 7, 8 of Table 2) has been set to use Design Thinking to support process improvement and to eradicate wasteful activities, endorsing the vision that better processes produce better outcomes steadily in time. This perspective is clearly in accordance with the Lean Thinking principles that acknowledge processes effectiveness as a pivoting role in businesses success (Womack & Jones, 1996). But, on the same time, it is in contrast with the concept that companies have to achieve a harmonic growth prioritizing Kaizen ahead of Kaikaku and radical Process Reengineering. We suggest that a possible way to overtake this tension between the two improvement strategies consists in a layered structure. At a higher layer, DT is useful for creating a communicable and pragmatic scenario of the future-state of processes, while at a lower layer, where strategy has to be implemented and executed (Favaro, 2015), an incremental improvement strategy is still perceived as the best solution to face the changes required.

Name of the company	Revenue Range	Products	Revenue Stream	Customer Relationship	Sector
Alfa	50-100	Rubber insulated low-voltage and medium-voltage cables	Products	Business to Business	Electronics
Beta	200-300	High tech heating systems and boilers	Products, spare parts, trainings	Business to Business	Energy
Gamma	200-300	Machines to process natural stone and metals as well as compound stone processing plants	Products, spare parts, trainings	Business to Business	Machinery
Delta	50-100	Domestic and commercial boilers	Products, spare parts, trainings	Business to Customer	Energy
Epsilon	500-600	Lawnmowers, lawn tractors and garden equipment	Products, spare parts	Business to Customer	Machinery

Table 1: The sample of researched companies

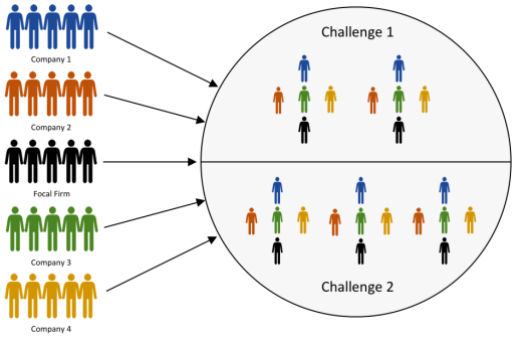

Figure 2: Teams management framework

Company	N°	Challenges definition's outcome	Opportunity exploration's winning plan
Alfa	1	How might we embed technology on a cable, whose performance depends only upon the material, to increase our market share?	A platform that collects big data form all the sensors placed within the company in a central data lake, distributing insights in the entire supply chain network (e.g. maintenance, stock management, sales, marketing).
	2	How might we redesign our production lines, which are esteemed lacking in the generation of insights, to reduce lead time?	A detailed new IT architecture for the production plant, inclusive of connectivity hotspots, information exchange protocols, PLC configurations, and the structures of MySQL databases.
Beta	3	How might we embed connectivity into a new product, to increase our market share?	The redesign of the maintenance process of one product, arranging the opportune and structuring control charts of some fundamental indicators.
	4	How might we use technology to transform a business model, which ensure an ordinary revenue stream, creating a new value proposition?	A plan for a new business model in which the customer receives the level of performance in line with the monthly subscription he is willing to pay.
Gamma	5	How might we help salesman, who have difficulties to get customer to appreciate product features, using virtual reality?	An interactive virtual reality system to ensure that the customer could evaluate realistically which product had a better fit with his needs.
	6	How might we help mechanical maintenance technicians, who have to manage a lot of knowledge, using technology to improve their performances?	A roadmap for implementing a big data analytics system with the aim to reduce the mean time between failure (MTBF).
Delta	7	How might we redesign the relationships with suppliers, which usually are non-standard, to raise the efficiency of co-design?	An architecture for organizing all the flow of information within the company with different databases based on a unique platform.
	8	How might we create a platform for all the stakeholders of product development, who are frequently not aligned, to enhance the quality of the outcome?	A redesign of the stage-and-gate product development organization adding a new PDM (product data management) software with an incorporated social network system.
Epsilon	9	How might we use the nine pillars of technology advancement to reduce the production shortcomings caused by the increased variety?	A roadmap to automatize some operations processes to tackle the problem of mass customization with automatic warehouses and automatic assembly line feeding systems.
	10	How might we embed connectivity into EPSILON's products, which should be more and more in keeping with the Ambient Assisted Living, to increase our market share?	A set of services for customers based on connectivity. The offering included the integration with weather forecast to plan when mowing the lawn, the remote access to the garden robot features, and possibility of the integration with Ambient Assisted Living systems.

Interdisciplinary teams and contamination as guidelines to tackle wicked problems

During the testing phase two practices have surfaced to tackle the complexity of Industry 4.0: interdisciplinary teams and contamination. We have noticed that the technicalities required for defining a DBS are rooted into different fields of knowledge (e.g. electronics, management, psychology, mechanics) and the effects that a DBS produces might be protean and wide-ranging.

Our research shows that one chance to dominate all this complexity is to encompass an interdisciplinary perspective: teams composed by different backgrounds have helped a lot in

designing strategies and, above all, operative plans. On the same page, we have tested the effects of contamination and cross fertilization arranging intercompany operative teams. In the feedbacks, it was recognized that the outcome has been largely influenced by the companies' best-practices that have been shared among members of the team alongside the project. The non-competitiveness has been an asset, because it has allowed the exchange of different cultures, provoking debates on how to share knowledge without fearing to lose key assets.

This is also representative of the organizational transition from the conceptual to factual layer of analysis, because in such a manner, a company is able to prototype the DBS before implementing it, using visualization tools (e.g. drawings, diagrams) in order to evaluate the potential scenarios, learn about strengths and weakness of the DBS, and equalize desirability and feasibility (Brown, 2009).

Knowledge and work in Industry 4.0

In most of the operative plans, teams have worked on framing architectures of systems that allowed the automatization of the operative tasks, and this have been quite discouraging for many employees, that believe that they will be overwhelmed by the digital transformation process. Results show that, at the moment, people are not marginalized by the technology advancements and Industry 4.0 work requires different skills and creativity. Data collected in the empathizing phases have also confirmed that most of the difficulties in getting grips with the DBS derived from the absence of a culture on Industry 4.0 among the members of the teams. It is a knowledge gap, that it might be fixed by giving managers and employees the possibility to take part in projects, seminars or workshop on the theme, where they may learn by practice, prototyping as they have done in the test we made.

Conclusions

While the digitalization of business within the Fourth Industrial Revolution is somehow given for granted, literature has not yet provided an understanding about how companies can define first and deploy then their own Digital Business Strategy.

The main contribution of our study concerns the proposal and test of an innovative method that can allow companies in coping with this goal. Bridging literature on Industry 4.0 and Design Thinking, the paper offers an original academic contribution, proposing and testing a structured method that adopts and adapts a well-known perspective (i.e. DT) in a new management field (i.e. the definition of a DBS). Overall, the results of our study have also important managerial implications and insights for advancing knowledge on how managers can deal with a wicked problem as the identification of a DBS.

The test of the method tells us that managers and employees appreciate the proposed solution because, this way, they can empathize with Industry 4.0 and explore opportunities of digitalization of their business in a structured and effective way. There was one recurring element in the interviews made to managers during the Challenge Definition phases: they argued that participating in this project have forced them and their companies to pursue innovation and the structure of the method has allowed them to feel free to explore a lot of possible opportunities. They claim that by questioning their business models they became aware of some unexplored disruptive elements they would have never get in touch with, as the possibility of investing on a new product or service for repositioning (e.g. case study Epsilon). Furthermore, the possibility of exchanging knowledge and practices with other companies has been positively considered by the companies as a way to find new solutions taking into consideration other different perspectives and experiences.

This research is subject to several limitations, each of which provides opportunities for future research. First and foremost, results are valid within the boundary conditions of this study, that is, a test run with the five analyzed companies, that are all in the manufacturing realm and all based in the same region. It could be worthwhile to replicate and extend our approach to other contexts and to a larger and diverse sample of companies.

Second, notwithstanding the Opportunity Exploration Phase proposed operative plans to deploy the DBS, the feasibility and effectiveness of these proposals have not been tested yet.

Finally, literature has highlighted both discrepancies in the descriptions of Design Thinking (Johansson-Sköldberg, et al., 2013) and different streams of research (Kimbell, 2011). In this regard, further academic studies would benefit from a unifying theory that seeks to depict the role of design in the management disclosure.

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