



Innovation game-changer or quixotic pursuit : the impact and influence of corporate Fab Labs in large organizations

Matthew Fuller

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DE L'UNIVERSITÉ PSL

Préparée à l'Université Paris-Dauphine

**Transformer les capacités d'innovation :
l'impact et l'influence des Fab Labs d'entreprise
au sein de grands groupes**

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Appended papers

This thesis is the extension to a series of three papers presented in the appendix.

Article 1: Fuller, M. & David, A. (2016). *“Resetting innovation capabilities: the emergence of corporate Fab Labs.”* 23rd International Product Development Management Conference, June 2016, Glasgow, Scotland.

Article 2: Fuller, M. & David, A. (2017). *“Making nothing or something: corporate Fab Labs seen through their objects as they cross organizational boundaries.”* 24th International Product Development Management Conference, June 2017, Reykjavík, Iceland.

Article 3: Fuller, M. (2017): *“Fitting squares into round holes: Enabling innovation, creativity, and entrepreneurship through corporate Fab Labs”*. In: Proceedings of the 21st International Conference on Engineering Design (ICED17), Vol. 2: Design Processes | Design Organisation and Management, Vancouver, Canada, 21.-25.08.2017.

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Chapter 1: Introduction

Most modern companies create and pursue strategies to develop or enhance their ability to innovate. With this objective in mind, several large companies established their own Fab Labs in recent years. Fab Labs are physical spaces devoted to creativity, innovation, and fabrication inspired by an academic public outreach program stemming from MIT in 2001 (Gershenfeld, 2005). This initiative offered shared, open access to advanced digital fabrication tools, such as laser cutters and 3D printers, in addition to a range of services including education programs and a global community. Fab Labs found in corporate settings were typically influenced by MIT's model. These initiatives position themselves as an organizational intermediary that creates new paths towards innovation by enabling any employee to contribute and develop their firm's innovation capabilities. To achieve the creation of these strategic, complementary innovation pathways, corporate Fab Labs typically emerge as distinct organizational entities that must gather resources, build relationships, and demonstrate their value.

Innovation pathways & autonomy

Fab Labs claim to create paths that enable any employee to contribute to new product development and innovation. However, they do not intend to supplant existing innovation processes or departments. Instead, labs typically operate as a distinct, complementary entity in parallel to traditional R&D departments, product research teams, or other formal entities that typically handle the firm's innovation and new product development activities. A “Fab Manager” or a team operates each lab. Most often, these employees report to another manager or executive who provides sufficient latitude for the Fab Lab to operate autonomously from other departments. This

independent configuration affords considerable freedom from the institutional constraints (Wheelwright & Clark, 1992) that tend to restrict innovation activities to specific departments or teams. Corporate Fab Labs frequently create two innovation paths to fulfill the central claim of developing innovation capabilities: assisting employees in developing an innovative proposal and cultivating an innovative mindset. Although the expected outcomes differ between these two essential paths that intend to create value for the organization, they both ultimately contribute to increasing a firm's innovation capabilities.

In the first path, activities in Fab Labs are intended to support the development of innovative proposals. Company employees are expected to use lab resources such as raw materials and digital manufacturing machines to create an object that represents their ideas. These activities work through an iterative process that progressively increase the fidelity of an emerging concept and work to eliminate flaws. Once a concept is sufficiently developed to be understood, it is anticipated that the object's employee-creators would use it to demonstrate the perceived value and validity of their proposal to a decision maker. If validated, the employee's idea may shift from the lab environment to another area of the organization better suited for continued development.

In the second path, individuals cultivate an innovation-oriented mindset as they choose to engage in lab activities and a lab community. Participation in labs is based on individual desire and remains unrestricted to specific job titles or qualifications. Community members are expected to make contributions based on their knowledge and skills, such as hosting a peer-to-peer training sessions or offering their ideas in a creativity workshop. As employees become familiar with innovative tools and methods used in the lab, it is anticipated that they will begin making more innovative

contributions in their day-to-day work. Additional gains are expected as community members support one another in their efforts to cultivate an innovation-oriented mindset in their respective departments.

Building capabilities as an organizational lightweight

As corporate Fab Labs work to fulfill their central promise of developing innovation capabilities, they gather and attract resources. The types of resources mobilized by the lab naturally increase as it grows from a fleeting idea to an established organizational entity, but overall labs remain resource-light compared to the organization's resources given to innovation. We briefly present three core resources gathered by labs—space, money, and people—and how they contribute to Fab Lab's two innovation pathways.

As a setting dedicated to digital fabrication and material objects, projects to create a Fab Lab typically start by looking for a suitable home. This foundational resource directly influences the types of activities present in Fab Labs based on space and location. The amount of space occupied by labs varies widely. Most labs occupy between 100 and 200m² (square meters), yet those figures range from approximately 30m² to over 1500m². On the smaller end of the scale, space is dedicated to fabrication activities. On the larger end of the scale, Fab Labs can house larger machines as well as larger teams. The largest space regularly houses nearly a dozen innovative projects during 90-day “sprints.” Similarly, lab location plays a significant role in several ways, including proximity and visibility. Proximity to large work groups plays an important part in the life of a lab, as most employees pass through between meetings, before or after hours, or during prolonged breaks. Similarly, labs placed in visible locations can pique the interest of passersby and entice them to inquire about the space. Highly visible locations also

help convey a sense of real legitimacy, associating prime locations with a strategic effort that attempts to make innovation everybody's business.

In financial terms, significant differences exist between labs. In some corporate labs, over a hundred thousand euros are allocated to build the lab in addition to a healthy operating budget. In other labs, creators start with only a few thousand euros, convince middle managers to sign machine leases, and acquire supplies through dumpster dives, flea markets, or purchases made on employee expense reports. However, unlike physical space, the presence or absence of funds does not necessarily alter the types of activities pursued in a lab. A nearly budget-less lab with large space can still incubate and support innovative project teams that receive funding from other departments. Several labs, including those with healthy operating budgets, encourage individuals to develop the ability to use whatever is on hand to create. Although financial resources are useful and necessary to equip a lab with machines, most labs choose to practice and encourage forms of frugal innovation (Radjou, Prabhu, & Ahuja, 2012) which enables them to reach a broader population of employees with low additional costs.

Finally, Fab Labs bring together significant human capital, which exceeds total financial and real estate costs associated with the lab by at least two or three orders of magnitude. In addition to a full-time staff member or small team who manages the lab, each employee who temporarily puts aside their day-to-day responsibilities to participate in lab activities contributes the value of their time to the resources found in Fab Labs. To be clear, we do not attempt to identify or measure the actual cost of time collectively contributed by each employee to lab activities. However, given the relatively small proportions of resources used by a Fab Lab compared to these firms reported R&D budgets (<0.1%), we consider these associated costs to be marginal.

Building relationships

Although some form of organizational autonomy is a signature characteristic found in most corporate Fab Labs, they do not operate in a closed-off environment. On the contrary: several labs position themselves as institutionally embedded entities (Leca, Battilana, & Boxenbaum, 2008) that create transverse innovation opportunities. In the eyes of several lab managers, they work to stimulate new relationships—both within and outside the company (Chesbrough, 2006)—while erasing organizational silos.

However, as a new organizational entity, the lab team must build new relationships and learn how the Fab Lab best interacts with other organizational functions and vice versa. These interfaces must enable continuity for innovative projects developed in the Fab Lab in addition to addressing more practical issues.

In the first case, an innovative object emerges from the Fab Lab, or an employee working to develop their own innovation-oriented mindset sets out to apply new practices in their day-to-day work. In both situations, these objects or individuals intend to fill a perceived organizational or market need. However, in most settings, those bringing new objects or practice have little to no organizational legitimacy to do so. To fulfill its promise, Fab Labs must establish channels that help innovative proposals emanating from the lab reach stages of consideration and potential acceptance within the organization. Put differently, Fab Labs must prepare and enable employees and their creations to cross multiple organizational boundaries (Carlile, 2004).

In the latter case, creating a new organizational entity with new or alternate practices inevitably requires mutual adjustments within the organization (Mintzberg, 1989). Adaptations must occur on multiple levels. For instance, in many firms, specific divisions

carry exclusive responsibility for various aspects of product development or exploration activities, such as R&D, product research, and design teams. These entities are not necessarily configured or managed to receive proposals from any employee or area of the company. Organizational entities frequently resist proposals originating from outside their team's boundaries (Katz & Allen, 1982); they must first adapt to develop the ability to consider innovative proposals developed outside their purview.

Conversely, teams working in Fab Labs must also recognize that the implementation of a seemingly simple proposal may result in significant organizational upheaval. Although the sources of inspiration used in their proposal may be innovative and valuable, the proposed object could remain poorly suited for broad-scale applications.

Additional adjustments occur at individual levels, as employees using Fab Labs temporarily adopt roles that differ from their everyday responsibilities. For instance, most organizations do not expect accountants to create a product prototype, or acoustic engineers to design new management performance indicators. Notwithstanding, labs claim to provide the tools, resources, and environment that collectively enable employees to do exactly that. To succeed, Fab Lab managers must develop relationships that reach far beyond the walls of the lab.

Demonstrating value

Fab Labs operate on the fundamental premise of offering any employee or team the ability to actively contribute to a firm's innovation capabilities. Within most organizations, Fab Labs are also expected to create and demonstrate value. The notion of value remains subjective, covering multiple dimensions deemed as desirable by an individual or group (Joyner & Payne, 2002; Wiener, 1988); examples include achieving economic performance, pursuing a strategic vision, or assuming social responsibilities. All Fab Labs studied indicated that at least one influential decision maker simply transposed the firm's existing key performance indicators (KPIs) for innovation—such as the number of patent filings—to evaluate the value produced by the Fab Lab.

Although using the same indicators enables comparison, it also constitutes a significant hurdle for even the most mature Fab Labs to compare favorably with other activities.

Overly simplistic comparisons infer that corporate Fab Labs should produce directly comparable outcomes to existing processes, ignoring the premise of creating new innovation capabilities to produce new types of outcomes by doing things differently.

Based on our empirical observations and interactions with several corporate Fab Labs, most managers and employees readily recognize that a Fab Lab is not the same as other divisions in their organizations devoted to new product design and development.

Although the two entities may produce some form of innovation capabilities, the abilities generated are not necessarily identical in nature. As such, most individuals consider that evaluating and comparing labs through the prism of existing R&D or innovation performance indicators presents significant limits. One executive described the outcome of this organizational tension as “absurd, but necessary for lack of a better option.”

The necessity described by this executive refers to management control, an essential function in any firm (Merchant, 1982). Fab Labs are not exempt from this organizational behavior. However, until a new set of evaluation criteria can be established and validated, “absurd” measurements or expectations will continue to apply to most corporate Fab Labs. This paradox (Bouchikhi, 1998; Lewis, 2000) points us towards the heart of our research problem: what value does a firm derive from outfitting itself with one or several Fab Labs, and how should organizations qualify that value?

In the following section, we detail the research questions deployed to explore the emergence and analyze the impact of Fab Labs in corporate settings.

Research Questions

The three research questions aim to identify what value firms derive from establishing a corporate Fab Lab, as well as the terms adequate for measuring and demonstrating that value.

Our first research question identifies various types of innovation capabilities found in organizations. Building on established frameworks for innovation capabilities (Börjesson & Elmquist, 2012; Christensen, 1997), we describe how Fab Labs generate or renew (Leonard-Barton, 1992) a firm's ability to innovate.

RQ1: What effects do corporate Fab Labs have on a firm's ability to innovate?

Our second research question focuses on the value derived from the material outputs produced inside corporate Fab Labs.

Fab Labs are equipped with a wide variety of tools and fabrication machines. One reasonably expects that these resources will be used to create new objects. Given our ambition to construct a relatively complete analysis of the impact Fab Labs have in corporate environments, we consider it essential to analyze the objects created in Fab Labs. Although these actual outputs may appear simple, in reality, even the simplest object and its status reflect a complex web of relationships and surroundings (Simondon, 2012). In addition, objects stimulate multiple reactions and interpretations. One individual might perceive an object as highly valuable, while another may see no value at all. As such, we formulate our second core research question as follows:

RQ2: What types of objects are created, and what do these creations reflect?

In the context of Fab Labs, the importance of this research question felt self-evident to measure performance and value based on specific outputs. However, existing scientific literature regarding innovative outputs tends to focus on aggregate outputs of a process rather than the individual components (i.e., evaluating the output of a brainstorming exercise vs. the individual significance of each idea). Given the importance of fabricating objects in Fab Labs, this presented us with an opportunity to develop and propose a new methodology for evaluating the organizational significance of objects created in Fab Labs and their capacity to create value by bridging organizational boundaries. Chapter 8 describes this effort in greater detail.

Finally, Corporate Fab Labs claim to enable employees to do things differently. To succeed this mission, Fab Labs must enable all individuals to break away temporarily or “disembed” (Leca et al., 2008) themselves from institutional roles, routines, and processes. Our final research question provides additional perspective by identifying the individuals who create Fab Labs and how they establish an alternate setting to produce innovative outcomes. We address this research question specifically in Article 3 through the lens of institutional entrepreneurship (DiMaggio, 1988; Hardy & Maguire, 2008).

***RQ3: Who is involved in creating Fab Labs, and how do
these individuals interact with the rest of the firm?***

In summary, corporate Fab Labs represent new entities that should enhance a firm's ability to innovate. Our principal research questions enable us to verify this in three ways. First, we establish the types of contributions Fab Labs are expected to bring to an organization and discuss those they could potentially make to an organization's innovation capabilities. Second, we propose a management tool to indicate the creation of new innovation capabilities by studying the objects created in Fab Labs. Finally, our last question verifies the claim that Fab Labs offer new ways of doing things by studying the trajectories undertaken by individual Fab Lab creators.

From a management perspective, the analysis and discussion surrounding these research questions could carry several significant implications. Results from RQ1 about innovation capabilities identify the types of contributions executives could reasonably

expect from a Fab Lab; we also introduce a more specific set of expectations. Objects studied through RQ2 offer a meaningful scale to gauge lab performance, and extend the perspectives created by the initial research question. Individual analysis of objects provides complementary perspectives to both Fab Lab managers and company executives. Using the same management tool, lab managers can adjust the type of assistance they provide to individual creators to develop significant objects, while executives and decision makers can reliably verify the progression of a lab's activities towards the goals it intends to address. Analysis through RQ3 helps to ascertain the degree of separation between existing institutional practice and new practices offered through Fab Labs. The operational nature of this analysis depends mainly upon strategic needs and priorities; some firms may prefer or desire a lab that's similar compared to existing practices, while others may find utility in labs as starkly different environments. These various managerial implications emerge and are discussed in Chapters 6 through 9.

Thesis structure

This document presents our research of corporate Fab Labs in three sections. The first portion—comprising chapters 2–4—introduces our research object, a theoretical background, and our methodology used in our study of corporate Fab Labs. The second portion—Chapter 5 and the appended articles—summarizes our core findings around our research questions. The final portion of this document—comprising chapters 6–9—deepens our understanding of these research questions and constitute the most significant contributions of the present research. Our conclusion then summarizes the main contributions of our research, presents future research paths, and outlines managerial implications based on our work.

Chapter 2: What are Fab Labs?

This chapter describes the emergence of Fab Labs and sets the stage for their introduction in corporate settings. The genesis of Fab Labs begins in the year 2001 as part of a new research program at MIT. As the program grew, Fab Labs continued spreading across the globe with the support of the Fab Foundation, an independent entity created by MIT to promote a global network of Labs. Parallel to the development of this growing network, Fab Lab-like settings began appearing in corporate environments. Although these initiatives claim no affiliation to the Fab Foundation, employees and outside observers quickly began referring to these corporate spaces as Fab Labs based on apparent similarities. This section concludes by exploring these similarities and discussing what it means to be a Fab Lab across multiple professions and research disciplines.

Before Fab Labs: from MIT's media lab to the Center for Bits and Atoms (1985-2001)

Established in 1985, the MIT Media Lab initially set out to explore how communication and expression might change when digital technology removes the constraints of physical media. That initial research focus on new digital media underlined differences between the “physical” and “digital” worlds, resulting in entirely new creations such as interactive multimedia experiences. These early projects focused on creating engaging and liberating digital representations of the physical world.

As early results from these research programs emerged, a handful of researchers began considering how the digital world could be represented in the physical world. In the 1990s, a handful of research projects began playing with the idea of transforming

traditional media to represent the digital world, such as electronic ink displays or bringing LEGO bricks to life through robotics.

As Media Lab Professor Neil Gershenfeld observed these physical objects transformed into representations of digital models, he considered whether or not things would inevitably “begin to think” (Gershenfeld, 2000; 2012). To explore this perspective, he established the Things that Think research consortium at MIT in 1995 to explore how the digital and physical realms could come together. At the boundary between these worlds sits an important catalyst necessary to create physical representations of digital models: digital fabrication.

The notion of digital fabrication is not recent, with the earliest digital fabricators originating at MIT in the early 1950s (Gershenfeld, 2015; Suh, Kang, Chung, & Stroud, 2008). Many machines, such as CNC milling machines used in modern manufacturing, alter materials to create a static physical representation of a digital CAD model. For instance, an automaker could use a plasma cutter to cut the steel necessary to build a car body. Once created, this transformation is practically irreversible: a car body is unable to change shape on a regular basis.

Gershenfeld's research group aimed to take digital fabrication a step further: could they use the same machines to create new digital materials that could be programmed by a digital model and reprogrammed as many times as wanted or necessary? (Gershenfeld, 2012b; 1999) In other words, could machines put together basic building blocks and later on disassemble and reuse them in a different form?

In order to begin fulfilling his research goals and vision, Gershenfeld identified two critical needs:

1. A research lab equipped with a full range of digital fabrication machines
2. A team of researchers trained in the safe operation and use of those machines

Fully equipping the research lab required substantial funding; to accomplish this goal a team prepared research proposals to apply for various grants. While waiting for funding approvals, Gershenfeld thought he could get a head start training fellow researchers and graduate students using the digital fabrication machines already present at MIT. In 1998, he created a course entitled “How to make (almost) anything,” to present and use machines in the lab. Only expecting a dozen or so graduate students from the Media Lab to participate in the course each semester, Gershenfeld was astonished to discover a waiting list with hundreds of undergraduate and graduate students signed up for the class. Reflecting on this experience, Gershenfeld explained “the next surprise was they weren't there for research, they weren't there for theses, they wanted to make stuff. I taught additive, subtractive, 2D, 3D, form, function, circuits, programming, all of these skills, not to do the research but just using the existing machines today.” (Gershenfeld, 2015)

In 2001, Gershenfeld received a \$14 million research grant from the US National Science Foundation (NSF) and founded the Center for Bits and Atoms (CBA) as a division within the MIT Media Lab. These funds allowed the CBA to develop their research efforts to “get one of anything to make anything.” (Ibid).

The early days of Fab Labs at MIT (2001–2008)

Following the CBA inauguration in 2001, Gershenfeld and his team quickly setup their research laboratory. As recipients of US Government funding, the CBA also needed to quickly figure out how to comply with a recently enacted federal law to measure the “social impact” of their research. As a team, the CBA devised a social experiment to create a small-scale replica of the digital fabrication tools found in his research lab. “We that thought rather than tell people what we're doing, we would give them the tools,” explained Gershenfeld (2012). They called the initiative a “Fab Lab,” a shortened form of both Fabrication Laboratory and Fabulous Laboratory (Gershenfeld, 2005).

In 2001, the Boston South End Technology Center (SETC) became home to the first Fab Lab. The initiative cost nearly \$100,000 for the purchase of machines and equipment; the SETC space contained the machines needed to make nearly any object. With support from MIT student volunteers, the SETC began offering training programs using Fab Lab equipment, primarily offered to youth from some of Boston's low-income neighborhoods. As researchers and others observed the impact of resources found in the Boston-area Fab Lab, they asked Gershenfeld and his team if they borrow their idea to make their own labs. Encouraged by MIT, Fab Labs quickly spread to initial locations in Norway, Costa Rica, Ghana, and India (Mikhak et al., 2002). Each new Lab, developed in partnership with a local academic or scientific institution, offered a complete set of small-scale digital fabrication tools, including laser cutters, plotters, 3D printers, and CNC milling machines (Gershenfeld, 2005).

Even though each Fab Lab provides—more or less—the same set of machines, Gershenfeld observed first-hand that lab members across the world use them to create substantially different objects (Ibid.). For instance, in India, lab users created inexpensive electronic devices enabling local dairy farmers to obtain fairer compensation by accurately measuring milk cream content. In Ghana, Fab Lab users launched a small business producing custom sandals. In Norway, the Lab equipment enabled locals to build an advanced wireless telecommunications network in a remote mountainous area to study local animal populations. At MIT, students created a web browser for a pet parrot, an efficient electric vehicle, or a backpack that records and releases screams when the user needs to quietly vent in a public setting and release their frustration later on in an appropriate and convenient setting.

Although these objects present significant material differences, they collectively represent a new type of creation: personally fabricated objects. Instead of creating objects individuals could buy or acquire through other means, individuals used lab tools and materials to create something that is economically unfeasible at a larger scale (Gershenfeld, 2005). Over time, Gershenfeld and his team perceived that Fab Labs could act as a key vector for social change by enabling individuals in resource-constrained environments to take advantage of otherwise impossible opportunities to create novel objects. This awareness constitutes a fundamental key to understanding Fab Labs and the general expectation of how they create value. We believe this expectation contributed to the appearance of labs in diverse settings, including in corporations. These expectations are explored in greater detail in chapter 6.

Formation of a global network of Fab Labs (2009–2018)

As the number of Fab Labs across the globe doubled annually and surpassed 100 locations in 2009, the MIT Center for Bits & Atoms established the Fab Foundation as an independent entity to support the development of labs. The global network of Fab Labs continues to grow, with approximately 1680 self-identified structures listed in the Fab Foundation's community directory at the time this dissertation is published (Fab City Research Lab, 2019). Today, Fab Labs in Europe represent over 54% of labs identified in the world, of which more than half of those are located in France and Italy (Ramella & Manzo, 2018). The United States is the only other country with as many initiatives as each of the two European countries.

The Fab Foundation provides access to core infrastructure to Fab Labs around the world. This support includes documentation used to help launch a Fab Lab, promoting a set of shared values found in the Fab Charter, and developing the Fab Academy with digital fabrication curriculum taught in hundreds of partner locations worldwide.

Partnerships between the Fab Foundation and several companies, such as 3D modeling software publishers Autodesk and Dassault Systems, offer Fab Labs with free or low-cost community software licenses. The foundation also organizes an annual FAB conference, with locations changing continents each year to facilitate participation from a global network.

In addition to the Fab Foundation's general support and resources, local networks constitute the majority of interactions between labs. Independent regional networks, such as the French Fab Lab Federation (FFF) or the FabAsia group, offer localized support, such as identifying and negotiating volume discounts with reputable suppliers,

providing tips to obtain proper business licenses or non-profit status, insurance contracts, and training. In many networks, discussions occur in local languages, extending the social impact of Fab Labs deeper than a community's English-speaking population.

What makes a Fab Lab a Fab Lab?

Although most Fab Labs build upon the same basic model established by MIT in 2001 and participate in a global network, each Lab remains an independent entity. Significant differences appear between Labs, including goals and objectives, even in similar cultures and settings. This causes us to consider the following: what we can draw from our empirical observations and existing scientific literature to identify properties that make a Fab Lab... a Fab Lab?

Throughout our research, we observed significant differences between labs, including those found in a similar culture or context. For instance, in Japan, one public university's Fab Lab formed a research partnership with MIT on digital fabrication, while another public university Fab Lab seeks to promote student entrepreneurship. In France, one Paris-area Fab Lab offers paid professional engineering consultancy services, while another Lab down the street in the same neighborhood considers that all projects should remain independent of commercial interests. The latter of these two cases is described by the respective Lab managers as a matter of market segmentation with similar strategies. The former example from Japan illustrates fundamental differences in strategy. From these observations, we learn that Fab Labs can differ significantly from one another in both strategic and ideological terms.

In parallel to our own observations, we surveyed scientific articles where researchers across disciplines describe their interactions with Fab Labs. A sampling of this literature confirms the multiplicity of strategies and ideas pursued and promoted by labs. These respective authors qualified labs as:

- A social impact program (Abramovich & Connell, 2015; Gershenfeld, 2005; Mikhak et al., 2002; Walter-Herrmann, 2013)
- A testbed for new entrepreneurial activities (Troxler & Schweikert, 2010)
- A new teaching/training resource (Blikstein, 2013; Maravilhas & Martins, 2018; Stager, 2013)
- A public library for the digital age (Belbin & undefined author, 2013; Burke, 2014; see also Gershenfeld, 2015; Taylor, Hurley, & Connolly, 2016)
- A knowledge-sharing network (Gershenfeld, 2012a; Wolf, Troxler, Kocher, & Harboe, 2014)
- A prototyping service provider (Ruberto, 2015)
- A lever for cultural transformation (Besson, Gossart, & Jullien, 2017; Lhoste, 2015; Ruberto, 2015)

The diversity reflected through this body of literature and seen throughout our empirical observations confirms that Fab Labs eschew a normative model or nature. In the eyes of the authors of the above-cited studies, each of these aspects describes—at least partially—what makes a Lab tick. These preliminary findings carry two significant ramifications as we orient our research. These considerations are summarized below and developed in greater detail in later sections.

First, we recognize that a multitude of interpretations and ambiguity surround Fab Labs. This does not surprise us when we recall the motives behind establishing the first Fab Lab. In order to comply with a new, ambiguous government reporting requirement (Gershenfeld, 2015), Gershenfeld and his team designed a strategically ambiguous (Eisenberg, 1984) experimental protocol (Gershenfeld, 2015). They chose to demonstrate social impact by observing what happens after giving individuals a subset of the tools found in their research lab. The ambiguous nature of Fab Labs benefited later initiatives as lab creators oriented them in response to various objectives. An attempt to establish a rigorous, enumerative definition of what a Fab Lab is or does would be invalidated as soon as a new interpretation appeared. Instead of limiting our study of Fab Labs based on a definition, we had to rely on trusted practitioners and extant literature to point us towards what they considered to be “Fab Labs.” This ostensive approach helped us learn how to intuitively recognize Fab Labs and Fab Lab-like environments. Consequently, we can also point them out to others. The analysis and conclusions presented in this document constitute an ostensive definition of Fab Labs that continues to evolve beyond the present work.

Second, based on the first position, we also consider that although contemporary Fab Labs have a “brand name,” they are not the first Fab Lab-like settings. For instance, during our research, we encountered “Useful Leisure Centers” (CLU: *Centre de Loisirs Utiles*), established in the early 20th century by state-owned mining companies in Northern and Eastern France. Initially imagined as a social program to curtail rampant debauchery in mining towns, CLUs provided mine employees and their families with free access to wood and metalworking tools and materials to make their own objects. The CLU aimed to teach miners new skills, reinforce camaraderie, share knowledge,

increase relative wealth, and improve overall quality of life. Based on all available historical documents, photos, in addition to our own observations and interviews, we can confidently conclude that CLUs are Fab Lab-like settings that substantially pre-date MIT's outreach program. Although our research aims to study contemporary initiatives, we consider that prior research conducted in similar contexts can inform our study of Fab Labs. The pertinence and limits of historical comparisons are presented where applicable.

Fab Labs found in companies

Prior to introducing Fab Labs found in corporate environments, we provide an important contextual note. The initiatives observed in our research are directly inspired by Fab Labs and other makerspaces (Lallement, 2015). They appear to walk, talk, and act like Fab Labs in most, if not all respects. All individuals interviewed—with one exception—considered they participated in a company-sponsored “Fab Lab.” In France, however, the use of this moniker encountered substantial resistance from several local, non-profit, or community initiatives. Opponents to the use of this term argued that the corporate nature of these spaces undermined the open, free (in the sense of *libre* and *gratis*) nature they believed to be intended by the MIT Fab Charter. French corporate Fab Labs sidestepped the issue that one observer qualified as a “puerile and churlish debate” by referring to themselves as corporate garages, makerspaces, innovation labs, or by their space's name in public settings. This debate appears to be mostly specific to France. In other countries we studied and observed, including the US, Japan, Germany, and South Korea, the Fab Lab designation appeared frequently in relation to corporate contexts. For the purposes of our research, we retain the appellation Fab Lab as it is the

term most frequently employed. At times, we employ the formulation “corporate Fab Lab” to avoid confusion.

From a fundamental standpoint, nearly any company with their own digital fabrication tools already has the partial makings of a Fab Lab. If a company were to provide access to these tools to individuals to see what they'll make, the organization would effectively reproduce the social experiment initially imagined by Neil Gershenfeld's team (Gershenfeld, 2015). Many companies, including small business, tolerate or encourage employee use of equipment outside of working hours for personal projects. Beyond these practices, Fab Lab-like environments in professional and corporate settings are not new. Known examples stretch back the turn of the 19th century. Documented instances include Thomas Edison's research laboratory which developed hundreds of new products and business (Millard, 1993), 3M's ProFab Lab established in the 1940s and 1950s to explore new materials and manufacturing processes (Minnesota Mining and Manufacturing Company, 2002), and autonomous structures like Lockheed Martin's Skunkworks (B. R. Rich & Janos, 1994) created at the end of the 1940s and still in operation to develop high-risk, top-secret projects.

Interestingly, when we asked individuals employed by such firms whether their company provided them with a “Fab Lab,” most interviewees responded negatively, even though they had been given access to advanced tools for personal use outside of working hours. Put differently, companies couldn't simply claim they provide their employees with a Fab Lab through the use of existing company tools. Instead, in addition to providing a collection of tools, Fab Labs must bring them together with some fundamental reason or purpose. In this section, we specifically consider the motives that led to the creation of the first corporate Fab Labs that emerged in the late 2000s, the

conditions surrounding more recent labs, and then discuss parallels with historical Fab Lab-like settings.

The earliest Fab Lab we could identify in a corporate setting appeared in a French energy firm. Inaugurated in 2009, the space was identified by its creator and users as a Fab Lab *ex post*. In other words, prior to 2014, this team hadn't yet heard of Fab Labs. The constitution of this lab began in the mid 2000s, when the company's CEO embraced and developed a specific method for creativity and innovation for all employees. One engineer quickly adopted the firm's innovation method. After finding the method useful in her own work, she wanted to share it with her coworkers and began training other employees. As this engineer worked with multiple teams throughout 2008, she felt the need for a space dedicated to promoting and enabling creativity. After finding an unused room in a basement, she established a "digital creativity lab" in 2009. The space included some tools to create basic prototypes as part of the innovation process. In 2014, the lab moved to a larger room at the ground floor featuring a larger space and digital fabrication machines. Two months after moving to the new location, a company visitor noticed the digital creativity lab and remarked, "Wow, you guys have your own Fab Lab here. That's great!" Although this was the first time the lab creator heard the term used, she quickly identified apparent parallels between her own work and other Fab Labs. These similarities range from offering the same types of tools and materials, training, and housing an active community dedicated to creating novel or innovative ideas and objects.

As Fab Labs around the world went through a period of rapid growth in 2012, a number of initiatives in corporate settings appeared. Several large, multinational organizations including Air Liquide, Orange, Renault, EDF, Saint Gobain, Sony, created their own Fab

Labs during this time period. During the same time period, companies like Siemens and Ford opted to forge partnerships with local Fab Labs and makerspaces instead of creating their own labs. In France, over thirty known initiatives emerged between 2013 and 2017, which is considered a relatively accurate and representative count by several local practitioners. To the best of our knowledge, no comparable datasets exist regarding similar initiatives in corporate contexts in other countries or regions. However, we are aware of at least forty additional corporate labs worldwide, identified progressively over the course of our own research. Our observations of labs in five different countries revealed significant commonality in methods and tools present, often inspired by resources developed in other labs. Each lab reflected some degree of influence from regional, national, and organizational cultures. For instance, several labs in Japan promote the importance of “monozukuri.” This Japanese word, which we are told lacks an appropriate English equivalent, was described by several individuals to us as the nobility of careful creation while integrating technical progress. A lab in Germany centered on the need to “hack” the larger organization as a subtle overture to Germany's hackerspaces established in the 1980s (Eychenne, 2012; Lallement, 2015).

Although new lab creations appear to have slowed, corporate Fab Labs continue maturing. In a handful of organizations, a single Fab Lab led to the creation of a global network of company labs. Renault, a French automobile manufacturer, counts over 20 labs spread across 5 continents found at various R&D, testing, and manufacturing sites. In addition to initiatives within organizations, multiple companies participate in an association of corporate Fab Labs. Representatives from each company come together regularly to share best practices, ideas, and resources. These professional groups also encourage members to find opportunities for companies to collaborate with one

another. In one case, a mobile phone technology company created a joint challenge with an automobile maker to explore applications for 5G wireless networks in vehicles. Based on reports from these two firm's project teams, these collaborative initiatives create significant value by identifying a mutually desirable innovation field and sharing the advantages of each company's respective expertise. Although challenge participants use digital fabrication tools found in Fab Labs, the primary value created in these projects originates from the labs role in structuring design-oriented activities (Hatchuel, Le Masson, & Weil, 2006).

Perspectives for Fab Labs

Following a phase of rapid expansion—particularly in Europe and specifically France and Italy between 2012 and 2015—the overall growth rate of Fab Labs decreased as the creation of new initiatives stalled. In France, new Fab Labs became scarce in early 2016, as a handful of locations shut down or consolidated with neighboring labs. Although our research objectives do not explore the underlying causes of this situation, the apparent lifecycle (Mintzberg, 1984) suggests that Fab Labs in their present form may have reached a peak.

Neil Gershenfeld (2015) describes his own vision of the Fab Lab lifecycle. In his view, advances in digital materials research will transform personal fabrication tools and substantially reduce the need for Fab Labs. Using the analogy of computers, he indicates that Fab Labs are like large, costly mainframes. Future developments will place digital fabrication into individual homes or even into pocket-sized devices, like personal computers in the 1990s and smartphones in the late 2000s. Just like mainframe

computing, the need for Fab Labs won't completely disappear, but they will only remain pertinent for specific use cases.

Conversely, scholarly studies of collaborative spaces (Fabbri, 2016) and makerspaces (Lallement, 2015), which include Fab Labs in their research scope, suggest an ever-growing need for these types of settings. In their eyes, Fab Labs and similar spaces qualify as “third places” (Oldenburg, 1989) for communities devoted to design and fabrication. In other words, the intrinsic value of Fab Labs isn't derived from the fabrications, but rather stems from the individuals who come together to design and create together.

On the surface, these viewpoints appear to make contradictory arguments regarding the future of Fab Labs. However, these views are not mutually exclusive. Although the tools used to fabricate objects continue to evolve and at some point may no longer require costly machinery, we may still need spaces devoted to designing and creating objects. In other words, future Fab Labs may be most relevant as spaces devoted to design and creation that happen to have machines, rather than laboratories with machines that also happen to encourage design. This important distinction ties in with our research surrounding questions RQ1 and RQ2. Consequently, instead of focusing on the possibilities offered by a machine, our theoretical basis presented in the following section focuses on Fab Labs as a means of encouraging and guiding innovation activities through design.

Chapter 3: Theoretical framework

As an emerging research object, a clear theoretical framework surrounding Fab Labs—especially those found in corporate settings—was not immediately apparent. Our preliminary observations conducted at the outset of our research indicated that the apparent objective for establishing a corporate Fab Lab was based upon increasing the organization's ability to innovate. This underlying objective is not unique to Fab Labs; many other organizational structures and business strategies were also designed to support innovation activities. Despite the apparent differences in both strategies and practices adopted to support innovation, we—like other colleagues exploring this emerging research object (Lo, 2014)—identified a fundamental theoretical framework frequently mobilized in scientific literature: innovation capabilities. As such, we believed we should adopt this notion as a starting point.

The framework presented in this chapter outlines the initial theoretical lens we wore as we began investigating our research object. We provide this overview to provide context to our overall research approach. While this chapter does not intend to provide an exhaustive literature review, it introduces the two theoretical notions that act as a common thread throughout our research. We complement this preliminary framing with more detailed theoretical framings in the appended research articles and latter chapters of this thesis, in addition to presenting a summary of other notions utilized throughout our work.

Initial framing

We recall that our research aims to identify and understand the contributions Fab Labs make in a corporate setting. To successfully accomplish this, we need a theoretical construct that provides a clear vision of the desired outcomes for a corporate Fab Lab. Once this core view is developed, we then expect to build upon it to help evaluate Fab Labs and whether they help organizations achieve their desired outcomes.

By desired outcomes, we refer to the underlying motivations and justifications employed to create a corporate Fab Lab, namely building a firm's innovation capabilities. A rich body of research describes the role of capabilities in organizations (Eisenhardt & Martin, 2000; Teece, Pisano, & Shuen, 1997) and how they can be developed, sustained, and regenerated (Leonard-Barton, 1992). We also briefly consider some of the specific challenges presented by this perspective.

A key challenge for a capabilities perspective comes in the form evaluating and measuring the performance and outcomes of innovation capabilities. This situation is partly attributable to the difficulty of tracking the often lengthy and erratic path followed by innovative initiatives, but primarily due to the impossibility of creating an isolated environment to control and compare the outcomes of a given strategy. A few researchers have made meaningful contributions by developing multi-dimensional models for assessing the overall performance of an organization's innovation capabilities (for example Björkdahl & Börjesson, 2012; Maier, Moultrie, & Clarkson, 2012). While these organizational-level models are supported by compelling arguments and data, they appear to be too general for our intended purpose. In our research, we're attempting to understand what outcomes are directly attributable to a specific capability

developed through a specific strategy. This proves to be a challenging task, and one to which we believe this research would ultimately make an initial attempt at solving.

To begin this effort, we started looking for a framework that allows us to assess whether the activities occurring in Fab Labs would result in unique capabilities that would be otherwise unfeasible for the organization to develop (Baldwin & Hippel, 2011). Due to the unique nature of these capabilities within the organization, we expected that their presence would ultimately stimulate forms of mutual adjustment. To follow these adjustments made in response to new objects and capabilities, we introduce and review the notion of boundary objects (Carlile, 2002; 2004; Star, 1989). This framework gives us the ability to observe the impact of objects created in Fab Labs at both a local level (i.e. inside the Fab Lab itself) and at a broader, organizational level.

After outlining the two theoretical bodies surrounding innovation capabilities and boundary objects, we conclude by examining the relationship between these theories and our principle research questions exposed in chapter 1. Extended development of each these notions are found in our research articles and later chapters of this document; we summarize their use in a table (Table 3-1) at the end of this chapter.

What are innovation capabilities?

We start by exploring the end goal Fab Labs aim to address: building an organization's innovation capabilities. On the surface, innovation capabilities appear to be a self-explanatory notion: they represent the ability for an organization to innovate. Many practitioners in corporate Fab Labs state their intent to complement their company's

existing mechanisms for innovation, or their ambition to develop new innovation capabilities.

The majority of research conducted around innovation capabilities adopts a perspective that the ability to innovate is the result of a process (Crossan & Apaydin, 2009). This approach implicitly suggesting that others can implement a similar process and obtain similar results. Observing the practice of applying common strategies to innovate, Hamel & Tennant (2015) suggested that most firms obtain mediocre results. They determined that this occurred when organizations approached innovation as something that is “bolted-on rather than baked-in.” In other words, the ability to innovate constitutes a core capability that must be developed within a firm prior to applying a process or working towards a specific, innovative outcome. Because Fab Labs are expected to build, support, and sustain these core capabilities for innovation, we want to review the nature of capabilities within an organization in general, and then proceed to review literature specific to innovation capabilities.

A capabilities perspective builds upon Penrose’s (1959) resource-based view of firms (Wernerfelt, 1984). Organizations develop core capabilities to perform activities essential to sustaining the business by allocating finite resources, such as time, money, space, and people. Given the inherent constraints of any organization, capabilities dynamically adapt to best respond to the constantly changing environments found both within companies and in their surroundings (Teece et al., 1997). Zollo & Winter (2002) define organizational capabilities as “...a learned and stable pattern of collective activity through which the organization systematically generates and modifies its operating routines in pursuit of improved effectiveness.” In other words, capabilities are the result of applying accumulated knowledge and experience to an organization's activities.

Although acquired knowledge can be continuously exploited, companies must continue use additional resources to formalize, coordinate, and implement new knowledge (Cohen & Levinthal, 1990; Levinthal & March, 1993; Nonaka, 1994). To ensure an organization can confidently pursue new activities, firms should routinely monitor, evaluate, and renew their capabilities (Schreyögg & Eberl, 2007). Empirical studies of organizational capabilities quickly note that replacing and developing new capabilities takes considerable time, effort, and resources. Since new knowledge sits at the heart of innovation, we expect that innovative firms actively work to develop and acquire new capabilities.

The notion of “innovation capabilities” is portrayed through multiple interpretations in scientific literature. Some distinguish innovation capabilities as the energy specifically enabling the development of novel and marketable innovations (Assink, 2006). Other influential voices frame innovation capabilities similarly, suggesting they constitute the lifeblood of an organization (Helfat et al., 2009), the ability to pursue radical endeavors (Hamel, 2003), or the ability to produce new systems and processes to compete (Utterback, 1994). Others approach innovation capabilities from a systemic vantage point (O'Connor, 2008) which holds that value originates from a system of resources rather than the aggregate value of individual resources.

In several situations, researchers identify capabilities by looking at the heart of innovation: the ability to develop new bodies of knowledge or learning how to do “different things in different ways” (Francis & Bessant, 2005). From this perspective, innovation capabilities take on a broader sense, representing the ability to generate new organizational capabilities. In this vein of reasoning, Fuchs et al (2000) consider innovation capabilities as a “higher-order integration capability.” To drive innovation,

firms use these higher-order capabilities to federate multiple lower-level capabilities. Other derivatives of this wider view offer basic frameworks outlining the fundamental building blocks for innovation capabilities: resources, processes and mindset (Börjesson & Elmquist, 2012). Such frameworks appear useful to describe and determine the relative intensity of efforts oriented towards developing innovation capabilities.

In addition to the wide range of interpretations surrounding innovation capabilities, identify capabilities with precision remains challenging in empirical settings. When evaluating an innovative project *ex-post*, neither researchers nor managers can perfectly identify which resources contributed to the success of that project (Lawson & Samson, 2011). Longitudinal studies of innovation capabilities also suggest that the presence of resources from a previously successful innovation project does not guarantee future success (Börjesson & Elmquist, 2011; Börjesson, Elmquist, & Hooge, 2014). In the same way, it's difficult to determine whether a resource's value to innovation is divisible from a larger system (O'Connor, 2008). In other words, deriving a meaningful set of capabilities from one organization that could potentially be applied elsewhere remains impracticable. These outcomes leave researchers and practitioners with the vision of an ideal objective yet no clear path to actually developing innovation capabilities.

This situation points us towards an alternate approach to innovation capabilities formulated by Hatchuel, Le Masson, & Weil (2006). In their view, classic organizational variables such as functions and networks are based on specific tasks to be performed. However, the means for creating and defining new tasks—innovation or “design”—is absent from these variables. For instance, an organization might identify an innovative concept to develop but the organization does not know which bodies of knowledge to develop that would transform this concept into a viable product. Conversely, a new body

of knowledge could be explored without knowing which new concepts could be developed into a new product family. In such situations, classical organizational structures cannot rely on existing standards, processes, or skills... they have yet to be defined. In an effort to resolve these challenges, these authors studied the behaviors of organizations who innovate intensively over long periods of time. Instead of observing isolated innovations or quantifiers measuring a “rate” of innovation, they focused on the organization's ability to evolve over time as their skills and know-how grew. As a result, they identified the behaviors of “design-oriented organizations” (DO2) (Hatchuel, Le Masson, & Weil, 2002) who demonstrate a non-routine ability to metabolize new knowledge. A combined historical and longitudinal approach covering several decades of intensive innovation activities in these types of companies indicates that such a metabolism results in major, frequent shifts to their organization's structures.

While developing an organization's innovation capabilities stands as an ideal goal for corporate Fab Labs, it remains inherently imprecise. To appropriately respond to our primary research questions, we retain two important considerations from this theoretical exploration of innovation capabilities. First, we want to establish a clear description of what Fab Labs offer to organizations. Existing innovation capability frameworks prove helpful to accomplish this task, despite their limited ability to indicate whether an organization *can* innovate over time with these fundamental building blocks.

Boundary objects

Once innovation building blocks are established and in-place, additional validation or tests are required to ascertain an organization's capability to metabolize and utilize them as part of their innovation activities. While these activities appear inherently “fuzzy” and difficult to measure (Khurana and Rosenthal, 1998), they do produce tangible artefacts—such as prototype objects—that can be observed and act as an indicator of knowledge creation and development (Mahmoud-Jouini, Midler, Cruz, & Gaudron, 2014).

The wide range of manufacturing tools freely available in Fab Labs enables and even encourages the creation of prototypes in many shapes and sizes. Once created, these objects can theoretically begin to probe and stimulate the organization's ability to transform and adopt new bodies of knowledge. However, this organizational metabolism doesn't always take place. In this section, we describe the theoretical role and nature of boundary objects as how they can be employed as a means of analyzing objects produced in corporate Fab Labs.

Organizational boundaries exist as a means of handling complexity within organizations (Nonaka, 1994) by creating smaller groups. Each group has a certain level of autonomy, influence, resources, and identity in relationship to the organization to accomplish their role (Santos & Eisenhardt, 2005). One natural consequence of boundaries is that various competencies develop their own specialized way of discussing, approaching, and resolving problems with objects. Despite these fundamental differences between each functional entity, some objects within organizations can be structured to cross boundaries and efficiently communicate information to all parties concerned. A single

object, such as a production planning schedule, can be used across functions for employee scheduling, payroll, purchasing, and sales (Carlile, 2002). However, organizational boundaries are a significant hurdle in NPD. Developing novel objects stretches existing knowledge (Reid & de Brentani, 2004; Le Masson, Weil, & Hatchuel, 2010), representing a type of organizational curveball that each function must apprehend and interpret. In his empirical study of over 106 cross-functional events in an NPD context, Carlile (2002) identifies three types of organizational boundaries with increasing levels of complexity: syntax, semantic, and pragmatic. We briefly summarize the nature of each of these boundaries.

Syntax boundaries originate from theories of digital communication. They describe the ability to reliably transmit and receive information using symbols—a type of common language (Shannon, 1949). Although effective communication is considered a determining success factor in organizational innovation (Damanpour, 1991) and in NPD activities (Katz & Tushman, 1981), the ability to communicate may break down as new objects are introduced (Carlile, 2002). Objects crossing syntax boundaries help create a common language, such as a prototype that initiates dialogue between organizational functions (Bogers & Horst, 2013).

Semantic boundaries describe situations in which different meanings are derived from objects, despite the existence of an established language or syntax. Successfully crossing this boundary implies that both parties are capable of using commonly understood terms to discuss objects (syntax) but also interpret objects (semantics). In other terms, successfully crossing this boundary instills a sense of “mutual understanding” (Nonaka, 1994). In this sense, a prototype can help identify respective challenges for future

production processes, intellectual property protection, or creating effective sales materials.

Pragmatic boundaries are crossed as specific problems introduced by novel objects are resolved. Reaching this point in boundary-crossing requires identifying and overcoming syntax and semantic boundaries (Carlile, 2002). Objects that overcome pragmatic boundaries provide a substrate that can be collectively altered and reshaped in a problem-solving process while incorporating specific knowledge held by each organizational function.

Creating objects that effectively cross organizational boundaries is not the only solution. Several established management practices are intended to reconcile the firm's dependence on organizational functions while mitigating the effects of boundaries in the fuzzy front-end, including the use of autonomous task forces (Wheelwright & Clark, 1992) or cross-functional project teams (Fredericks, 2005). Empirical evidence underscores the utility of these approaches in NPD settings (Patanakul, Chen, & Lynn, 2012), they do not necessarily eliminate organizational boundaries. Often, the effects of such boundaries are simply felt later on. In the case of autonomous project teams, functional boundaries are transformed into project-team boundaries. In the case of autonomous project teams, team members retain their role as a representative of a specific function. To the best of our knowledge, management practices in scientific literature do not describe configurations that temporarily blur out organizational functions. In our analysis, we will thus consider both the nature of boundary objects created in Fab Labs, but also the possibility that the Fab Lab itself constitutes an organizational boundary object.

Summary of theoretical frameworks

Both innovation capabilities and boundary objects serve as foundational pieces underlaying our research; extended literature reviews for each of these notions are found in Articles 1 and 2 respectively. Later stages of our work also build upon two additional theoretical notions: management ideas and institutional entrepreneurship. The following table (Table 3–1) outlines our development and use of each of these notions throughout our work.

Table 3–1. Theoretical foundations overview

Theoretical notion	Key references	Developed & primarily used in
<i>Innovation capabilities; dynamic capabilities</i>	<ul style="list-style-type: none"> - Teece, Shuen, & Pisano, 1997 - Lawson & Samson, 2011 - O'Connor, 2008 - Börjesson & Elmquist, 2011 - Christensen, 1997 	Article 1; Chapters 6 & 7
<i>Boundary objects</i>	<ul style="list-style-type: none"> - Simondon, 1958 - Star, 1989 - Carlile, 1998; 2002; 2004 	Article 2; Chapter 8
<i>Management ideas</i>	<ul style="list-style-type: none"> - Kramer, 1975 - Abrahamson, 1996 - Birkinshaw, Hamel, & Mol, 2008 - Rauth, 2015 	Chapters 6 & 7
<i>Institutional entrepreneurship</i>	<ul style="list-style-type: none"> - DiMaggio, 1998 - Garud, Hardy, & Maguire, 2007 - Hardy & Maguire, 2008 - Battilana, Leca, & Boxenbaum, 2009 	Article 3

Chapter 4: Methodology

Plunging into the dynamic world of corporate Fab Labs offered multiple unique opportunities to uncover these emerging spaces, primarily through action-based research methods (Kaplan, 1998) and active participation in lab activities. This section briefly recounts the origins of our research, describes the process that enabled us to work with additional labs, and outlines the types of data collected. This dataset covers four corporate initiatives in extensive detail and over two dozen additional labs from three countries. Finally, we present the specific approaches adopted and methodological challenges in responding to our primary research questions.

Origins

The opportunity to observe and analyze emerging initiatives in large corporate settings stems from a partnership with the team from Renault's Creative People Lab and Renault's HR director at the end of 2014. At the time, lab co-creators Lomig Unger and Mickaël Desmoulins worked in Dominique Levent's creativity and vision team. Alongside the group's executive HR Director and three other firms, they participated in a six-month collaborative research project we coordinated to better understand the HR and management implications surrounding corporate Fab Labs. The results of this initial collaborative research project addressed a professional audience, presented in a detailed yet accessible 108-page report. This initial research partnership enabled us to become familiar with labs, begin exploratory data collection and observations, and introduce us to a community of practice of corporate Fab Lab managers.

Over a period of four years, from 2014–2017, we visited, studied, observed and participated in activities of dozens of Fab Labs, with key research activities taking place in the labs of four large multinational firms. While our efforts focused on those found in corporate settings, we also made a conscious effort to explore multiple types of labs and other “makerspaces” (Lallement, 2015) to get a clearer sense for the similarities and specificities of these various spaces. Although the differences between labs found in “open” or “closed” environments present an interesting research opportunity, we deliberately set aside those questions to enable a more detailed exploration of organizational implications of a corporate Fab Lab.

Data collection methods & dataset

During our field studies in corporate Fab Labs, our interactions resulted in a collection of detailed notes from interviews, photos, videos, sketches, presentations, official documents, policy and procedural memos, and objects, including some that we created ourselves or participated in the creation process with others. Secondary data collected includes books, articles written by Lab managers or participants, and journalistic articles written about the corporate spaces we observed.

The following two tables summarize the locations studied as part of our research, presenting a list of labs found in corporate settings and other types of spaces we observed. We present these respectively in Tables 4–1 and 4–2.

Table 4–1. Corporate Fab Labs studied

Industry	Company (Parent company)	Employees	Lab Name	Year Lab Created
Chemical	Air Liquide	> 40 000	iLab	2012
Transportation	Air France Industries	> 14 000	MRO Lab	2017
Aerospace	Airbus	> 70 000	Protospace	2014
Electronics	Alcatel-Lucent (Nokia)	> 50 000	Le Garage	2013
Energy	Areva NP (Orano)	> 40 000	L@B Areva	2009
Software	Autodesk	> 7 000	Pier 9	2013
Financial	Cardif (BNP Paribas)	> 9 000	Cardif'Lab	2014
Software	Dassault Systems	> 10 000	3DS Lab	2013
Energy	EDF	> 150 000	I2R	2012
Software	Evosoft (Siemens)	> 500	Fab Lab Nuremburg (partnership)	2012
Energy	GRDF (Engie)	> 10 000	“Fab Lab”	2015
Household appliances	Groupe SEB	> 20 000	SEBLab	2013
Energy	GRTgaz (Engie)	> 3 000	Lab	2016
Retail	Leroy Merlin (Adéo)	> 85 000	BricoLab	2013
Automotive	Nissan	> 140 000	—	<i>proposed</i>
Telecom	Orange	> 150 000	Thinging Orange Lab	2012 (inactive)
Telecom	Orange	> 150 000	Le 3e Lieu	2016
Energy	Pacific Gas & Electric (PG&E)	> 23 000	IoT Lab	2016
Automotive	Renault	> 125 000	Renault Creative Lab	2012
Electronics	Ricoh	> 110 000	Tsukuroom	2015
Manufacturing	Saint Gobain	> 180 000	StartLab	2015
Transportation	SNCF	> 150 000	Les 574	2015
Aerospace	Snecma (Safran)	> 15 000	Atelier Innovations Services	2013
Electronics	Sony	> 85 000	Sony Creative Lounge	2014

Table 4–2. Other Fab Labs & makerspaces studied

Lab Name	Location
American Center Korea	Seoul, South Korea
Artilect	Toulouse, France
Ateliers Leroy Merlin	Ivry-sur-Seine, France
Carrefour Numérique	Paris, France
Centre de Loisirs Utiles	Bollwiller, France
DeVinci Fablab	Courbevoie, France
DMM.make	Tokyo, Japan
Electrolab	Nanterre, France
Fab Lab Provence	Marseille, France
Fab Lab Seoul	Seoul, South Korea
Fab Research	Yokohama, Japan
FabCafe	Tokyo, Japan
Fablab Descartes	Noisy-le-Grand, France
FabLab Digiscope	Gif-sur-Yvette, France
Fablab Kamakura	Kamakura, Japan
FabLab Kannai	Yokohama, Japan
FabLab Setagaya	Tokyo, Japan
FabLab Shibuya	Tokyo, Japan
FabLab Tsukuba	Tsukuba, Japan
FacLab	Gennevilliers, France
Galvanize	San Francisco, United States
ICIMONTREUIL	Montreuil, France
Idea Factory	Gwacheon, South Korea
La Casemate	Grenoble, France
La Fabrique Numérique de Gonesse	Gonesse, France
La Paillasse	Paris, France
Laboratoire d'Aix-périmentation et de Bidouille	Aix-en-Provence, France
Le Petit FabLab de Paris	Paris, France
Makers'Base	Tokyo, Japan
Proto204	Bures-sur-Yvette, France
RocketSpace	San Francisco, United States
SQYLAB	Saint-Quentin-en-Yvelines, France
Station F	Paris, France
Usine.io	Paris, France
Volumes	Paris, France
WoMa	Paris, France
YOUFACTORY	Lyon, France

In the corporate Fab Labs identified in Table 4–1, we employed multiple methods to constitute our dataset, primarily through documents, interviews, participation, and direct observation. We describe how we performed each of these key activities. The subsequent table (Table 4–3) summarizes the resulting outputs that constituted our empirical dataset from corporate Fab Labs.

Documents/presentations

Although our research builds principally upon primary data sources, documents and presentations about corporate Fab Labs provided additional context and secondary insights. Most of these documents were obtained by asking lab creators if we could view what they had presented to the firm’s key decision makers when they proposed creating a lab. Additional documents collected include the lab’s marketing materials such as videos and flyers and recorded presentations of lab creators recounting their lab creation to corroborate interview data. We also gathered press articles with accounts of corporate Fab Lab users and managers.

Interviews

Interviews constitute the backbone of our empirical dataset, with over two hundred interviews conducted. Our research builds primarily on data stemming from 121 semi-structured interviews, where questions focused on lab origins, how the interviewee(s) used—or didn’t use—the lab, its tools, the objects they created, and the organizational connections they made as a result of participating in the lab. During these interviews, we took detailed, typed notes at an effective typing speed of 110 words per minute. Where practical, we also made an audio recording of the interview. Comparisons between our notes and the recordings reflected a level of near-verbatim fidelity. All verbatim quotes

found in our articles and this document were either directly typed during the interview and noted as verbatim through the use of quote marks (“ ”) or extracted from an audio recording post-interview.

Our unstructured interviews most commonly took place as informal, and occasionally opportunistic conversations. Due to these circumstances, light notes (bullet point lists) were typed during the conversation on a mobile phone, including any applicable verbatim indicated using the same technique as our semi-structured interviews. These conversations appeared crucial. Additional notes, details, and impressions were added to these notes shortly after the interview.

Participation

The level of participation in lab activities varied from lab to lab, depending on whether we were invited for a visit/tour or extended an open, ongoing invitation. In the former case, our visits typically lasted an hour and our participation was limited to short, opportunistic conversations with whomever was in the lab. In the latter case, we returned to the lab to observe activities as frequently as schedules would allow.

As we observed labs, we remained open and receptive to invitations to participate, transitioning from an observation mindset to active participation. Most frequently, this would happen when an individual was learning how to use a piece of software or tool in the lab. When confronted with a challenge, they would simply ask if we knew anything about what they were trying to do and might be able to help out. In most cases, we did have some technical knowledge that helped resolve their issue. If not, we would suggest working together to troubleshoot or solve the problem.

Following these interactions, we would return and document in our observation notes the events that had just taken place and additional elements from our unstructured conversations. When possible, we kept an eye on other activities and interactions that took place in the space while we were participating with a lab user and immediately noted them.

In two labs, our participation was more significant. In one space, we actively contributed to the operation and maintenance of lab equipment and conducted three group training sessions. In another space, we were invited to co-lead a week-long, cross-departmental innovation challenge. This initiative was designed to introduce lab users to building and programming a robot and create new relationships across organizational departments. During these higher-intensity periods of participation, our observations were supplanted by photos, videos, training materials we helped produce, and keeping a daily log of our recollection of that day's activities. While these participations resulted in lower-fidelity data, they were instrumental experiences that opened the door to ongoing research.

Observations

Observations constitute the second-largest source of information in our dataset, following interviews. Collectively, these observations resulted in:

- Notes about activities and interactions occurring in the lab. We recorded these while present in the lab
- A photo library with nearly 3,000 photos of people, spaces, and objects made in labs. These photos were taken during lab visits

- A research journal used to gather thoughts and impressions in the hours and days following a period of observation
- Self-produced documentation of equipment, programs, activities, schedules, and resources available in a lab

The types of observations we performed and associated outputs evolved over time. For instance, during visits made at the outset of our research, we focused heavily on detailed documentation of the tools found in labs. Our analysis of objects found in Article 2 led us to determine that the physical tools and materials available had little impact on the ability for individuals in a lab to produce an object that could cross organizational boundaries. As such, we adapted our techniques and started collecting less detailed information about tools.

Table 4–3. Summary of data collection methods & dataset

Documents	
Executive presentations	16
Other presentations	36
Online videos	19
Press articles	48
Interviews	
Semi-structured interviews	121
Unstructured interviews / conversations	116
Participation	
Number of organized activities led/co-led	8
Active participant in organized activities/events	12
Observations	
Days observing lab activities	85
Photos of objects, spaces, individuals	2897

Question-specific methodologies

We also needed to appropriately respond to each of our three research questions using our empirical dataset. To accomplish this, we identified and deployed a specific methodology for each question. We describe these specific applications below.

Identifying innovation capabilities (RQ1)

RQ1: What effects do corporate Fab Labs have on a firm's ability to innovate?

As corporate Fab Labs intend to develop corporate innovation capabilities, we wanted to qualify the types of capabilities they enabled. Despite the simple nature of our question, responses varied widely. This result felt unsurprising, based on the wide variety of innovation roles (O'Connor, Leifer, Paulson, & Peters, 2008) held by employees and their personal perspectives. For instance, one engineering manager thought the lab offered a creative outlet for “frustrated” individuals, and that a space for self-expression would improve originality and productivity in their employee's day-to-day work. Another engineering manager in the same department thought the creation of an innovation-oriented community of practice (J. S. Brown & Duguid, 1991; Orr, 2014) best embodied the principal contributions of a lab.

As we collected a series of responses, we attempted to directly regroup them into basic categories established in existing models of innovation capabilities (Börjesson & Elmquist, 2012; Christensen, 1997). These frameworks categorize capabilities as either resources, processes, and culture or mindset. We considered whether various labs would focus on developing different types of capabilities; could similar sets of capabilities developed in a lab impact several organizations in similar ways?

Although the authors of these frameworks establish clear elements that fall into each of the three categories, frequent crossover appeared as we coded our interview response dataset. For instance, in the case of the lab as a creative outlet, we could qualify the physical space as a resource, self-expression as a process enabled by the existence of a new resource, and that process would result in a more imaginative and productive

mindset applicable to day-to-day work. Further questioning in our interview about the lab as a community of practice suggested that the introduction of a new innovation-oriented mindset amongst employees would lead to the constitution of an “innovation community.” This community becomes a resource to support and enhance that state of mind; the process of new individuals joining the community increases available resources and reinforces mindset. These two examples underline the difficulty of establishing various actions or initiatives as discreet, independent capabilities. Instead, we adapted our view of capabilities based on intent. In other words, a lab creator could primarily intend to transform their organization's innovation culture, or their ambition may be to provide a space for an otherwise innovative group of employees. Although the resulting physical space may appear similar in both contexts, the former initiative oriented efforts towards developing mindset capabilities, while the latter developed resources. The notion of “orientation” becomes central in our analysis surrounding RQ1; we use it to distinguish specific intent to contribute to a firm's innovation capabilities from complementary resources, processes, and mindset that naturally emerge in the process of developing the intended capability.

“What are you even making?” (RQ2)

RQ2: What types of objects are created, and what do these creations reflect?

The above title reflects a question frequently heard from newcomers to the Fab Lab, co-workers, or management. Beyond curiosity, it often comes with an expectation of producing *something* of value. Although most organizations value intangible elements such as learning, knowledge, and culture, tangible outputs help validate their existence. Fab Labs provide a wide range of tools to create tangible objects, conveniently

encouraging a rapid transition from tacit knowledge (Nonaka, 1994) to a materialized form. Based on this, we quickly determined we would need to look towards other research fields for methods for identify analyze individual properties that contribute to the value of a novel object.

In our search for an appropriate methodology, we looked for a framework that would help us qualify the value of nascent, emerging objects like prototypes. Several authors, most notably those associated with Stanford's d.school (Design School), highlight the value of prototyping processes (Buchenau & Suri, 2000; Kelley, 2010). However, their value analysis focuses on final outcomes obtained with the help of prototypes in general, such as improved communication or rapid idea validation. While helpful, we wanted to specifically identify what an individual object created in Fab Labs represented in terms of value. Jouini, Midler et al's (2014) analysis of how objects from individual cases contributed to a larger design process. Their work inspired us and pointed us towards both Carlile (2002) and Star's (1989) frameworks for boundary objects.

These theoretical tools describe how objects can become increasingly sophisticated as they cross three key organizational boundaries: syntax, semantic, and pragmatic. In order to determine which boundaries an object crossed, we would need to identify the role(s) of the individual(s) who created the object, their purpose for creating it, how the object was used, and how its use changed over time.

We took our catalogue of 539 photos taken in four different corporate Fab Labs and started by identifying all visible objects created in a lab environment. With a series of objects identified, we wrote a short description of the object based on notes and narratives given to us by lab managers and creators. Additional elements identified for

each object included the size of the design team, the types of machines used in the fabrication process, in addition to iterations made on a single object or whether multiple forms existed. With these descriptive properties identified, we then coded each object based on the types of organizational boundaries they appeared to cross. Finally, we analyzed groups of objects categorized by organizational boundary type for similarities and differences. This analysis enables us to understand which labs produce objects capable of directly contributing to innovation capabilities.

Identifying the actors behind Fab Labs (RQ3)

RQ3: Who is involved in creating Fab Labs, and how do these individuals interact with the rest of the firm?

A group of dedicated individuals stood behind most corporate Fab Lab initiatives we studied. Whether their mandate came from self-motivation or management, each person expressed feelings of responsibility towards their company. Most desired to help their organization progress with an increased ability to innovate.

In order to respond to RQ3, we began by listing multiple descriptive characteristics of Fab Lab managers we interviewed. This included age, gender, educational background, number of years of professional experience, number of years working as an employee of the firm, and whether managing the lab occurred as part of a new or existing job role. We then compared this data to identify recurring profiles found in our population, and found one predominant profile with several secondary profiles. Further interviews enabled us to analyze these profiles and characterize these individuals as institutional entrepreneurs.

We then wanted to identify how these individuals interact with their firms and what they did. As we considered the former aspect—how these individuals innovated—we then wanted to qualify to what extent these employees disembedded themselves (Leca et al., 2008) from institutional practices. Using our interview data, we identified descriptions of key interactions between lab creators seeking resources and “embedded” actors (DiMaggio, 1988) who granted resources, such as a executive committee who decides whether to grant funding to a lab. We observed how these individuals positioned themselves, often as bridge-builders to improve the organization's ability to innovate, or other times as internal agitators looking to disrupt the status quo.

To address the latter aspect—what these individuals do to continue interacting once resources are granted—we used the innovation capability lens established with of our primary research question (RQ1). Using our prior identification of resources, processes, and mindset produced by a lab compared with existing innovation capabilities, we could then consider whether the labs succeeded in maintaining a significantly different structure in an organization. Stated metaphorically, could Fab Labs remain a square while still fitting into the firm's round hole shaped structure?

Conclusion

Although corporate Fab Labs are new, emerging entities with sparse exposure in scientific literature, we approached them as an organizational entity intended to create value. We gained exposure to multiple labs in corporate environments as well as other “makerspaces” in different environments and identified the expectations of stakeholders. Through this process, we understood that most organizations expect labs

to create value by enhancing the firm's ability to innovate. From this viewpoint, we then could adapt a set of existing frameworks to analyze the lab's organizational impact in the innovation space. This was done by identifying innovation capabilities originating from labs, the types of objects produced in labs and their life inside the organization, and the extent from which lab creators detached themselves from institutional practices to establish a more innovative environment. The following sections present the analysis based on our research and discuss the organizational and managerial implications of a corporate Fab Lab.

Chapter 5: Summary of Appended Papers

This chapter summarizes the three appended papers as part of the doctoral research. Each paper is presented in order of our research questions. The thesis describes the research material and key contributions to the core research questions of this thesis. We then explore the findings from each article in greater detail in the following chapters of the present document.

Article 1: Resetting innovation capabilities (2016)

Considering the wide range of interpretations of innovation capabilities found within most organizations, the first article develops our initial research question (RQ1) to identify how Fab Labs are perceived or intended to contribute to a firm's innovation capabilities.

To gather the widest possible variety in individual interpretations of how corporate Fab Labs help a company innovate, we used snowball sampling techniques with the help of our core research partners to constitute a sample of eighteen firms in four countries: France, Japan, United States of America, and Germany. We then conducted a series of sixty-nine exploratory and semi-directive interviews conducted across these firms to identify how labs contribute to innovation capabilities. We then performed an inductive analysis, coding our research material with a basic innovation capabilities framework (Börjesson & Elmquist, 2011; Christensen, 1997) which identifies the resources, processes, and mindset generated by Fab Labs.

Our analysis identifies a variety of perceived capabilities, with most initiatives focusing their attention on one of the three types of capabilities. In multiple instances, we

observed an apparent duplication by labs of existing capabilities, most frequently resources. In other words, several firms already had pools of digital fabrication machines used for prototyping activities. However, we observed that the prerequisites for accessing both types of resources differed substantially: existing tools often required significant budget and management approvals for an operator or outside vendor to produce a mockup. In contrast, the Fab Lab provided free access to those resources. This leads us to develop the notion of “resetting” innovation capabilities. We discuss how resets can take multiple forms, such as temporarily returning back to a simpler organizational structure, or the ability to set aside a body of established design rules (Baldwin & Clark, 2000). We then consider how these resets can either add to an organization's existing capabilities—much like special task forces or autonomous project teams (Wheelwright & Clark, 1992)—or progressively work to change an organization's approach to innovation (Börjesson et al., 2014).

Article 2: Making something or nothing (2017)

Fab Labs contain the tools required to make (almost) anything (Gershenfeld, 2015); this article which addresses our second research question (RQ2) establishes what those objects represent within an organizational setting. The significance of an object evolves over time and takes on different meanings to other actors within a given ecosystem (Simondon, 2012). In order to describe the nature of objects emerging from labs, we employed Paul Carlile's (2002) theoretical model of boundary objects that qualifies objects based on the types of organizational interactions they enabled. Each of the three levels of “boundary crossing” in his framework indicates an increased degree of complexity and indicates the relative maturity of each object.

To constitute our corpus of objects produced in Fab Labs, we tagged all identifiable objects found in a series of over 500 photos taken at multiple intervals in four different labs—two in France and two in Japan. We then wrote a qualitative description of each object based on information obtained during our interviews, observations, and follow-up questions. In addition, we detailed the types of interactions that followed objects as they either remained in the lab or travelled across different areas of the organization. Finally, we looked at the total number of objects found in each level of boundary crossing on a per-lab basis.

Our discussion and analysis begins by describing the characteristics of objects found at each of the three levels of boundary crossing, including a series of examples and images. We continue by observing the primary types of objects that emerge from each lab. We note that objects became increasingly more complex over time in all labs. We also observed that individuals using one lab created multiple highly complex objects leading to significant organizational change. This observation leads us to consider and discuss corporate Fab Labs as a type of boundary object that intentionally fall outside conventional departments and functions. As the interactions between an organization and a lab mature, increasingly complex objects can successfully emerge. We conclude by proposing the use of objects as a proxy for the relative maturity of labs.

Article 3: Fitting squares into round holes (2017)

The environment created by most founders of corporate Fab Labs intentionally differs from other spaces found in the firm, often as a means of stimulating creativity and promoting collaboration. By creating an intermediate space that is neither office space nor meeting rooms nor production facilities, Fab Labs tends to deviate from established

practice and often looks and feel out of place to institutional observers. Through this article, we wanted to see how Fab Lab creators operated to figuratively fit a square shape into an institution focused on round, silo-shaped holes. In order to address our third research question (RQ3), we built upon DiMaggio's (1988) theory of institutional entrepreneurs.

We began with our data from interviews of corporate Fab Lab managers who described their experience as they created the new space. Our initial analysis compared a series of descriptive elements to identify common characteristics between lab creators. We then worked through our interview data to identify key moments where lab creators worked to obtain resources from decision makers—institutional actors—to pursue their project. We then performed a similar analysis with interview data from managers and decision makers.

In our discussion and analysis, we explore the relative distance between the Lab creator—an institutional entrepreneur—and decision makers. Put differently, we attempt to describe the extent to which lab creators must disembed themselves from organizational practice. We then cross this analysis with results about innovation capabilities (RQ1) to explore whether or not innovation capabilities vary or increase based on the degree of disembeddedness of lab creators. Finally, we discuss whether Fab Labs remain ostensibly different entities that retain their properties to develop innovation capability as they mature and are institutionalized

Our exploration of this research question is limited to the appended article and not developed further in the present document.

Chapter 6: Fab Labs as management ideas

In our initial study of how corporate Fab Labs develop innovation capabilities in Article 1, we identified multiple types of resources, processes, and mindset that these spaces provide. These three elements constitute the foundational building blocks of innovation capabilities (Christensen, 1997).

When our analysis of Fab Labs broke innovation capabilities down into these granular elements, our findings suggested most resources, processes, and mindset found in most labs are not necessarily new to the firm. In fact, the vast majority of the elements found in Fab Labs already exist within firms, namely resources and processes for innovation. This leads us to reason: if the basic ingredients for building innovation capabilities already exist within an organization, how is the lab itself expected to impact the organization's ability to innovate?

To explore this, we shift away from our prior focus on the building blocks Fab Labs provide to innovate. Instead, we want to consider what a lab represents to an organization's management team to understand their rationale for creating a lab. To fully explore this perspective, we must first build this managerial representation from our empirical material.

Constructing a managerial representation of corporate Fab Labs

To establish what representation of Fab Labs managers have in mind, we start by referring to their own statements of expected outcomes. To do this, we reviewed our dataset compiled as part of Article 3, comprised of interviews with executives, managers, and employees to identify their stated objectives and intended outcomes as they created or used a lab. We make a clear distinction between objectives and outcomes. By objectives, we refer to what managers expect the lab to directly accomplish or produce. By outcomes, we refer to indirect accomplishments or byproducts expected as a result of the lab achieving its objectives. In some instances, collected responses also included the activities or means employed to obtain the desired objective or outcome. We included this information in order to control for implicit objectives and outcomes.

We then performed open coding on these statements to identify objectives, outcomes, and strategies, which refer to the activities or means used to achieve the desired outcomes. We then regrouped these attributes in higher level categories, as presented in the following table (Table 6–1).

Table 6–1. Stated objectives of corporate Fab Labs

Objective (Level 1)	Intended outcomes (Level 2)	Strategies (activities/means) (Level 3)
Increase innovation capabilities	Growth & business opportunities	Creating new growth opportunities
		Support startups
		Develop new types of businesses
	Organizational transformation	Providing resources to drive change
		Unify teams
		Enable learning
		Stimulating connections across the organization
		Increased agility & flexibility
		Support innovative project teams
		Expand our innovation ecosystem
	Supporting activities/means	Support creativity
		Demonstrate novel concepts
		Generate disruptive concepts
		Test ideas quickly
		Bring ideas to life
		Make ideas tangible

In order to positively identify the managerial objectives for Fab Labs, we started by reviewing the sample of statements from our interview data that explicitly formulated objectives. We found that all converged towards a specific objective for Fab Labs: increase their organization's ability to innovate. We then considered the indirect outcomes expected of Fab Labs. An apparent dichotomy emerges regarding the indirect outcomes expected by utilizing a Fab Lab: enabling growth and organizational

transformation. These are both clearly identified outcomes of innovative processes (Crossan & Apaydin, 2009). As such, we were confident in formulating the following working hypothesis: individuals who qualify a Fab Labs' purpose through its indirect outcomes implicitly expect the lab to increase their organization's ability to innovate and achieve these outcomes.

In order to test this hypothesis, we asked individuals we interviewed previously to positively describe how the Fab Lab would help them achieve their expected outcomes. In all instances, respondents explicitly mentioned some form of the word “innovate” coupled with a qualifier such as “increase,” “augment,” “enhance,” and “improve.” During this process, we did not identify a corporate Fab Lab created to fulfill some other objective that might also produce the same types of indirect outcomes. For instance, we have not heard of Fab Labs specifically intended to enhance employee well-being, or Fab Labs as a recruiting tool adapted to attract highly sought-after skillsets. As a result, we conclude that the primary objective for corporate Fab Labs is to enhance an organization's ability to innovate.

This result does not preclude a potential shift in the managerial intent regarding Fab Labs. On the contrary, our analysis opens the door to generating and pursuing these potentially desirable alternatives. That said, to date, we have yet to identify a fundamentally different managerial rationale for Fab Labs in their current form.

At this stage, we recall that Fab Labs are not alone in working to enhance innovation capabilities in firms; numerous approaches compete to fill this organizational need (Crossan & Apaydin, 2009). Based on these data points, we developed a working hypothesis that Fab Labs are a specific type of solution being “hired” (Christensen, Hall,

Dillon & Duncan, 2016) by organizations with a specific goal in mind. In addition to our working hypothesis, we also observed certain behaviors where labs increased in visibility from little-known undertakings to several high-profile initiatives. Over time, an increasing number of labs involved corporate executives and major political figures in highly public settings, such as Sony's Chairman & CEO in 2014 or the President of the French Republic in 2016. These patterns suggested to us that labs carry some level of fashionability (Abrahamson, 1996).

We intuitively recognize the pattern of a widely-accepted, fashionable solution to commonly encountered organizational problems in management studies. For instance, in the early 20th century, Taylor's research at Bethlehem Steel resulted in the creation of "scientific management" as a means of improving employee productivity. Peter Drucker's "management by objectives" (Drucker, 1954) helped establish a clear understanding of goals between employees and employers. The "balanced scorecard" aims to turn strategy into measurable action (Kaplan & Norton, 1996). These examples are theorized through the notion of "management ideas" (Birkinshaw, Hamel, & Mol, 2008).

At this stage, our analysis and intuition suggest that we assess whether "Fab Labs" are a management idea. In the next section, we present a concise review of scientific literature surrounding management ideas. We then test our working hypothesis of labs as a management idea by specifically identifying the presence of essential components. We do this using an established framework that highlights a management idea's rhetorical and technological properties (Rauth, 2015). In the following section, we use these characteristics and our empirical data to deductively determine if corporate Fab Labs could appropriately and accurately be qualified as a management idea.

Management ideas

Management ideas reflect “fairly stable bodies of knowledge about what managers ought to do” in a given situation (cited in Birkinshaw et al., 2008; Kramer, 1975). Put differently, management ideas represent a potential strategy one can use to resolve a commonly encountered challenge. As they emerge, management ideas take on common characteristics regrouped in two distinct dimensions: rhetoric and technology (Birkinshaw et al., 2008; Rauth, 2015). The former justifies when and why a management idea should be applied; the latter describes what and how managers should apply it. The following section summarizes existing literature to describe how management ideas emerge and diffuse, then outlines the key elements that compose the substance of a management idea: rhetoric and technology.

When most individuals hear of a management idea, it has already reached an advanced stage of diffusion. Most management ideas emerge out of practice as an internally-crafted solution to a given problem in an organization. For instance, lean manufacturing (Ōno, 1988) originated at Toyota in response to challenges with their production system. Similarly, design thinking (Kelley, 2007; 2016) emerged as part of industrial design firm IDEO's user-centered design process. These firms applied these new practices in response to their specific needs and organizational settings. However, for an idea to spread outside a firm, it must shift from a context-specific initiative to a generally-applicable principle (Giroux, 2006). By this, we mean that some level of work is performed to make a given solution appear generic in nature. The most “contagious” (Røvik, 2011) management ideas carry vague or “interpretable” (Benders & Van Veen, 2001) elements, meaning other individuals could easily find meaning and choose to

apply them to their circumstances (Kieser, 1997). For instance, the principle of *kaizen*, which signifies continuous improvement was initially embodied by Toyota's lean manufacturing process (Ono, 1988). Despite the fact that this principle emerged in the context of the automobile industry, the success attributed to this principle and its interpretable character made it applicable in nearly any industry or setting.

If elements of a management idea appear too specific, managers may consider a given management idea inadequate to solve the problems they currently face. On the other hand, a management idea that becomes overly vague—such as “lean” methods (Hines, Holweg, & Rich, 2004)—becomes subject to multiple permutations that may stretch beyond the realm of actual utility (Zbaracki, 1998). This tension created by the inherent ambiguity of simplification underlines an important characteristic of management ideas: interpretability (Giroux, 2006).

Interpretability plays a key role, since the organizational motives for adopting management ideas vary significantly, ranging from pragmatic considerations to political or cultural motives (Sturdy, 2004). Management ideas lend themselves as “convenient” (Giroux, 2006) solutions that lend themselves to specific situations.

In addition to interpretability, management ideas with high levels of adoption of management ideas benefit from some level of fashionability (Abrahamson, 1996). Although popularity levels do not exclusively determine whether something is a management idea, many ideas do become highly fashionable when they become accepted as the standard solution to a common problem. These fashionable management ideas often result in prolific exposure in professional and academic literature as well as popular media, culture, and practice. While fashionability can

explain how a management idea may spread, they are not indicative of the effectiveness of the management idea. In reality, assessing the effectiveness of a management idea requires evaluating the outcomes obtained through its application. As such, the ability to distinguish management fad from fashion comes after a substantial period of time (Abrahamson, 1996; Benders & Van Veen, 2001).

Fashionability and interpretability address how management ideas spread and whether they make sense to a wide variety of situations. However, at their core, management ideas are fundamentally a vehicle for contents that an organization's management team must interpret, adapt, and potentially apply. A simple framework helps dissect these contents: rhetoric and technology (Rauth, 2015). Simply put, these two dimensions respectively reflect when and why a management idea could be pertinent, as well as what and how it could be applied. This rhetoric/technology framework constitutes a fundamental tool employed in our analysis of Fab Labs as a management idea; as such we expose both dimensions below.

Rhetoric carried by management ideas includes two key elements: a name and claims that justify the necessity of a management idea. We illustrate this dynamic using two common management ideas: *open innovation* and *Management by Objectives (MBO)*. In his treatise on open innovation, Henry Chesbrough (2006, p. 19) frames the need for open innovation with the following claims: "No company can afford to rely entirely on its own ideas anymore, and no company can restrict the use of its innovations to a single path to market. All companies will need to improve their ability to experiment with new technologies in new markets." In a similar example, Peter Drucker (1954, p. 117) presents "management by objectives" (MBO) in the following terms: "What the business enterprise needs is a principle of management that will give full scope to individual

strength and responsibility, and at the same time give common direction of vision and effort, establish team work and harmonize the goals of the individual with the common weal. The only principle that can do this is management by objectives and self control.”

The perception created by Drucker and Chesborough's statements suggests overly broad strokes and seemingly facile reasoning that fails to account for organizational complexity. The universal claims cited we above suggest that all managers, regardless of the company's size, industry, geographical location, or any other specific conditions face these problems. However, this does not undermine the effectiveness of the management idea. On the contrary: the vagueness of such statements actively contributes to the management idea's interpretability, as long as the claims appear plausible to the receiving audience. Based on these author's assertions, one reasonably presumes that both *open innovation* and *management by objectives* position themselves as solutions to resolve respective challenges in a similarly universal way.

Additional arguments to justify implementing a management idea could include references to implementation by competitors or other highly esteemed firms, success stories, or foreshadowing potential failure. Short success stories add credibility to management ideas. For instance, Toyota's implementation of lean manufacturing practices (Liker, 2003; Ōno, 1988; Womack, Jones, & Roos, 2008) contributed substantially to their ability to increase product quality, which enabled them to attain market dominance. Similarly, IDEO's ability to create highly innovative products takes root in their user-centric, design thinking approach (T. Brown, 2009; Kelley, 2007; 2016). These rhetorical snapshots ascribe significant success associated with the implementation of a concept that solved a general problem; however, they contain few specific elements about how that problem was actually solved. This blend of ambiguity

surrounding specific success stories ultimately helps contribute to the interpretability of the management idea.

Technology provides information on how to solve the problems portrayed through rhetoric; it conveys the principles, practices, and techniques needed to successfully implement a management idea (Rauth, 2015). When presenting technological aspects of management ideas, interpretability is maintained by presenting general or ambiguous elements, meaning they can apply in multiple settings or result in multiple interpretations. In other words, showing how others have successfully applied a given management idea is not presented as a prescriptive path, but rather a general body comprising multiple approaches. Principles describe certain values or objectives an organization should seek. Practices refer to general types of principle-based activities, while techniques refer to pragmatic instructions that would pursue those practices.

We illustrate the relationship between principles, practices, and techniques while maintaining interpretability with the following example. When we consider the management idea *open innovation*, the principle “open” appears to be both general and ambiguous, especially when paired with the equally ambiguous notion “innovation.” Practices to embrace this ideal notion could include a broad type of activity called “partnering with others.” These practices also appear both general and vague—specific techniques such as “creating an internal venture capital fund to partner with startups” or “establishing a joint venture” can increase potential applicability. Examples illustrating principles, practices, and techniques typically refer to specific company or situations, often in the form of a case study. This approach diminishes interpretability. However, one can also counteract the effects of providing specific cases and increase

generality by offering multiple examples coming from diverse industries and organizational types.

Fab Labs as management ideas?

In the previous section, we identified our working hypothesis that Fab Labs could be a management idea. We determined that they are viewed as a solution to a specific organizational problem or challenge. We also determined that this state constitutes one attribute of management ideas. We also identified a pattern of diffusion and fashionability surrounding Fab Labs, which are additional characteristics of management ideas. We now want to extend our analysis to determine whether the notion of a corporate “Fab Lab” conveys the elements required to be considered a management idea. In addition, we also want our analysis to look for traits of interpretability. To accomplish this, we reviewed our empirical data looking for elements indicating an interpretation of rhetorical and technological elements associated with Fab Labs. We present our analysis and findings in the following sections.

Rhetorical elements of the Fab Lab management idea

In this section, we discuss the properties and use of “Fab Lab” label, followed by a detailed analysis of its' associated rhetorical claims. We recall that rhetoric describes a label and claims to support why a firm would need to implement a management idea. Labels summarize or “brand” the management idea; in some cases they also provide a contextual clue about what the idea is intended to do. For instance, the label *lean manufacturing* sends a signal that this idea can simplify a complex, industrial activity. One may also implicitly interpret simplification as a source of greater performance or

reduced costs. Labels are then supported by rhetorical claims; they provide a central claim or premise that summarizes the expected benefits of the management idea. Threats and warrants provide secondary support to the central claim (Rauth, 2015). Based on the supporting relationship between each of these elements, we start by analyzing the Fab Lab label, and then identifying central claims, threats, and warrants.

Label

A name is the most visible part of a label. However, a label is more than just a name. A label also reflects a management idea's "theorization" (Birkinshaw et al., 2008), or in other words the rationale for adopting the ideals embodied by a particular management idea. The choice of label is also significant to the acceptance of management ideas; "a good name consolidates, it lends [a management idea] a language and a market value," (König, 1985; cited in Kieser, 1997). We consider consistent use of a label across a heterogeneous set of actors and individuals to be an indicator of interpretability. In this section, we want to determine the effective interpretability of the Fab Lab label.

To measure interpretability of a label, we will examine the extent to which a wide variety of actors employ it. The use of a label amongst pockets of individuals reflects a form of jargon, which indicates low interpretability. On the contrary, common use amongst a highly diverse sample of individuals suggests increased levels of interpretability. We assume that use is commensurate to levels of consolidation. The universal use of a label indicates perfect consolidation. This universal pattern exists in some disciplines, such as the notion of "real numbers" in mathematics. However, in management practice, universal use of a label appears improbable. As such, to identify

consolidated use of the label, we want to identify circumstances that present consistent use patterns of the Fab Lab label.

To do this, we start by looking at the basic linguistic properties of the Fab Lab label that might limit its use under certain circumstances. We then present the use patterns of the Fab Lab label observed during our research within and outside of corporate environments. Finally, we conclude by discussing the degree of consolidation presented by the Fab Lab and its resulting interpretability in a management context.

As a name, the expression “Fab Lab” carries three key linguistic characteristics. First, it's short and memorable, composed of two three letter words that use two of the same letters in the same location of each word. The sounds of these words rhyme.

Second, the underlying meaning of the name—fabrication laboratory—is intuitively understood, even in its contracted form. The use of the contraction “lab” is more frequently used in contemporary English than the word “laboratory” itself (Davies, n.d.). The use of “fab” could be explained by the fact that the English language contains few words that begin with “fab-”. Specifically, the following words use the “fab-” root, listed based on their use in contemporary English (Davies, n.d.) from most frequently used to least frequent use: fabric, fabulous, fabricate, fable, and fabulate. When these five words are associated with the word “lab,” the pairing with the mod “fabricate” intuitively provides the most coherent meaning when compared to the four alternatives. Until an enterprising individual or organization creates a compelling portrait of a “fable lab” or a “fabric lab,” we make the assumption that most individuals will naturally make the conceptual association and pairing resulting in a “fabrication laboratory.”

In addition to the intuitive understanding of the contracted words “Fab” and “Lab,” we also posit that the meaning of these words is naturally understood and associated with value creation. Laboratories act as a source of new knowledge and discovery through scientific experimentation. Research laboratories such as Edison's labs (Millard, 1993) and corporate R&D labs produce significant value. The word fabrication, derived from Latin, signifies the action of making. In other words, a Fab Lab's underlying meaning is understood as making new knowledge and discoveries. These are crucial ingredients in the innovation process valued by most organizations. In other words, Fab Labs may be conceptually associated with fabricating value.

Finally, while “Fab Lab” is an English expression, it has considerable impact in foreign languages that use the Latin alphabet. The translated form of “fabrication laboratory” contains both “fab-” and “lab-” in at least twelve languages, summarized in Table 6–2:

Table 6–2.
Translation of “fabrication laboratory” in foreign languages

Language	Expression
Danish	fabrikationslaboratorium
Dutch	fabricatie laboratorium
French	laboratoire de fabrication
German	Fabrikationslabor
Indonesian	laboratorium fabrikasi
Italian	laboratorio di fabbricazione
Norwegian	fabrikasjonslaboratorium
Portuguese	laboratório de fabricação
Romanian	laborator de fabricatie
Spanish	laboratorio de fabricación
Swedish	fabrikationslaboratorium
Turkish	fabrikasyon laboratuvarı

From this, we determine that the Fab Lab label can intuitively convey meaning and easily circulate in a large part of the world.

In summary, the “Fab Lab” name is easily said, recalled, and understood as a source of value in many parts of the world. From our standpoint, this suggests that the Fab Lab label presents few linguistic barriers to consolidated use, in addition to conveying a sense of value. In other words, most people can intuitively find a general meaning and associated value with no additional knowledge beyond the words.

Despite these linguistic virtues, the use of the label is not universal, and in some cases, it is intentionally avoided. To understand its limits, we want to describe patterns of use we observed, both outside and within corporate environments.

Outside of corporate environments, the Fab Lab label competes with several other labels describing similar settings, including makerspaces, hackerspaces, and living labs (Capdevila, 2013). At first blush, this situation indicates the Fab Lab label has limited consolidating ability, which would limit its interpretability as a management idea. As such, we wanted to explore the use patterns associated with these competing labels.

Although the competing labels appeared synonymous to many individuals we encountered, legitimate distinctions between them exist (Lallement, 2015). These differences are typically characterized by the social and economic outcomes intended for the space, or the role institutional actors play within the space (Capdevila, 2013). Most spaces we encountered adopted one of the more specific terms rather than the Fab Lab label to identify themselves. When we participated in gatherings of practitioners, we generally found the representatives of those spaces identified themselves using their preferred label. However, that practice shifted when we observed representatives of

self-identified makerspaces, hackerspaces, and living labs speak to newcomers in their spaces, the media, and the general public. In those instances, several individuals began employing the label “Fab Lab.” When questioned about this practice, several individuals indicated a necessity to ease comprehension in order to gain greater public support. From our standpoint, we find this use behavior suggests the Fab Lab label acts as a stronger, consolidating label compared to other commonly used labels in general contexts. Despite use of competing labels amongst experts and specialists, this finding reinforces the interpretability of the Fab Lab label.

In the vast majority of corporate environments we observed or learned about, the Fab Lab label was absent in formal settings. Labs are consistently branded using some other, specific name, such as Creative People Lab, Creative Lounge, Tsukuroom, iLab, Bricolab, Protospace, or The Garage. In other words, corporate labs observed eschewed the Fab Lab label and adopted a unique identity. That said, we consistently *heard* the words Fab Lab used as a quick reference to describe the general, underlying model for the corporate lab and its value proposition. Similarly, despite the existence of a specific lab name in most companies, we often heard individuals refer to the space as a Fab Lab (i.e. “Want to go to the Fab Lab?” instead of “Want to go to the Bricolab?”). From our standpoint, the latter situation described is analogous to calling a generic product by a brand name, such as referring to facial tissues as “Kleenex” or cola as “Coke.” These use patterns observed suggest that the Fab Lab label simultaneously consolidates an easily understood value proposition and brand name, especially in a corporate setting.

Given the apparent utility of the Fab Lab label, we questioned why corporate lab creators chose to create a specific identity for their lab. Some individuals expressed

doubt about using the Fab Lab label due to potential trademark infringement.¹ Most individuals indicated that they chose a name that had significance and meaning to the group of individuals that created the lab. The name reflects something that appears unique in nature that unites a diverse body of contributors. Based on our own observations, we also suggest that a unique identity may also act as an instrument used to manage perceptions. For instance, a perception of differentiation is suggestive of a competitive advantage. While the Fab Lab label effectively provides context and conveys general meaning and value, we believe a unique lab name can also be used to embody the ambitions and aspirations of its creators.

As a brief aside, we also found that some corporate lab names refer to earlier settings found in the firm's history. For instance, a lab named “the Garage” refers to the specific garage where that company was founded. This practice intrigued us; we briefly recall this notion in our discussion found in the following chapter.

Our analysis of the linguistic properties and use patterns of the Fab Lab label demonstrate consolidated use of the label in multiple settings. From a linguistic perspective, the expression is short, catchy, and easily understood nature in at least a dozen widely-spoken languages. We believe this enhances its ability to consolidate. When we looked at use patterns outside and within corporate environments, we

¹ *To the best of our knowledge—and contrary to belief repeatedly encountered throughout our study—MIT, the Fab Foundation, and its affiliates hold no trademarks protecting the Fab Lab name. When questioned about the intellectual property strategy regarding the Fab Lab name, a spokesperson at the Fab Foundation alluded to ideological and pragmatic considerations that guided their decision to keep the name as part of the public domain.*

observed a common trend that uses the label to convey generally understood meaning and value. Although limits appear as actors in corporate settings replace the term with their own brand or identity, use of the label persists to provide context. As such, we consider the Fab Lab label supporting this management idea highly interpretable.

Central claims

The central claim stands as a core characteristic of a highly interpretable management idea and reflects its general appeal. By this, we mean to say that a management idea's core value proposition is understood and considered desirable across a variety of diverse settings and circumstances.

As described earlier in this chapter, the central claim surrounding corporate Fab Labs converges around enhancing an organization's ability to innovate by introducing a fabrication laboratory. To the extent that enhanced innovation performance has considerable appeal and strategic relevance in most settings, the central claim made by corporate Fab Labs appears pertinent and generally appealing.

Based on this generally appealing central claim, we expected the Fab Lab management idea to be interpretable by most individuals in nearly any corporate setting. In order for this working hypothesis to hold true, individuals presented with the Fab Lab management idea should be able to articulate some form of implementation that would be valuable to their organization.

Instead, we encountered several actors who did not find this central claim believable or applicable to their environment. Most critical arguments focused on the emphasis of fabricating objects in order to innovate. For instance, several individuals considered Fab

Labs pertinent to groups of engineers in industrial firms, but didn't believe it could benefit other types of employees in the same organizations. Two innovation executives we interviewed from separate financial services firms stated they didn't see how labs could bring value in service-oriented companies. Other critical considerations suggested that a lab's benefits appear primarily in complex environments. Most owners of small and mid-size businesses we interacted with suggested that Fab Labs appeared necessary in large organizations stifled by silos. When asked to clarify whether a lab in general could create value for their firm, they responded by indicating their belief that their firms would gain little to no benefit from having their own lab.

This finding suggests that while the premise of building innovation capabilities appears generally desirable, the specific proposition made by Fab Labs is not interpretable in a variety of organizational settings. These individual reactions collectively paint a portrait that limits the general nature of the central claims employed by corporate Fab Labs.

In addition to individuals who looked critically at the Fab Lab's ability to fulfill its central claims, we also encountered individuals who adopted and adhered to the central claim while ignoring the technological elements of the management idea. Consequently, some companies we observed called any initiative that promotes innovation capabilities a Fab Lab. For instance, an executive of a large Asian firm thought a nap room was a Fab Lab since it was intended to enhance productivity and innovation. Another industrial firm suggested that their R&D department already had all the fabrication tools and space needed to “continuously renew” their innovation capabilities, and thus concluded that their manufacturing area constituted a Fab Lab.

The existence of these multiple interpretations indicates high levels of ambiguity around Fab Labs, which is suggestive of a management idea's interpretability (Giroux, 2006).

These types of highly interpretable central claims certainly facilitate the diffusion of the management idea due to their nearly universal appeal. However, an overly general central claim facilitates interpretations that eventually strips labs of the meaning communicated by the Fab Lab label: fabrication and laboratory. This largely masks the benefits associated with a unique space dedicated to these activities and creates confusion that undermines the legitimacy of the Fab Lab management idea.

However, the observed state of ambiguity surrounding Fab Labs is not permanent; in reality the claims that support management ideas can evolve over time as an idea's underlying theorization matures. Early stages of diffusion benefit from claims that pique widespread interest using overly general terms. In later stages, central claims remain interpretable but become more nuanced (Rauth, 2015). Most frequently, this maturity appears by constructing claims suited for specific applications of a management idea, such as introducing a "Fab Lab for small businesses" that directly responds to concerns identified previously in this section.

The current state of broad general claims suggests that the Fab Lab management idea has the opportunity to mature and eliminate confusion. To accomplish this, we suggest a shift in central claims to focus on unique outcomes originating from fabrication-related activities in a lab-like environment identified through our empirical analysis. We develop this avenue in detail in the following chapter; at present, we return to our analysis of the supporting rhetorical claims that support the central claim—threats and warrants—as well as the technological elements conveyed by the Fab Lab management idea.

Threats

Threats support a management idea's central claim by explicitly outlining the risks an organization currently or potentially faces. Implicitly, the adoption of a management idea acts as a strategy in response to those risks.

Similar to the other rhetorical elements of a management idea, interpretability of threats is prerequisite to diffusion. In order to assess the interpretability of threats, we first determine whether the stated threats are generally applicable. By this, we mean that threats should appear significant to management across various conditions. If the threats appear meaningless, irrelevant, or insignificant, the impetus for the management idea disappears. Once we identify areas where the threats appear applicable, we can then shift lenses to determine whether the Fab Lab management idea is interpreted as an adequate response to those threats. We adopt this additional approach to avoid identifying false positives, where management recognizes the validity of a threat but doubts the validity of the management idea's central claim. In situations where both of these conditions hold true, interpretability of threats conveyed by the Fab Lab management idea is considered high.

Throughout our empirical study, we identified two primary threats conveyed by individuals proposing the creation of a Fab Lab in their organization. The first portion of our analysis—assessing general applicability—introduces the two threats and supporting rationale drawn from our interviews. We then compare them, and finally discuss their interpretability in terms of generality and ambiguity.

The first core threat we identified relates to innovation as a means of promoting growth. It suggests that a Fab Lab should be implemented because organizations “cannot afford

to miss out on a new billion-dollar business” (Airbus, presentation on 6 May, 2015) because their employees couldn't obtain the resources needed to get started within the firm. The underlying risk conveyed by the proponents of this threat, sometimes explicitly, is that employees capable of developing ideas with the potential to generate significant value will leave the company to create their own startup or go work for a competitor. In both instances, the organization would face increased competition and declining value creation potential.

The proponents of this threat typically articulate their arguments in a similar fashion. They introduce the threat by recognizing their organization's existing abilities to innovate through existing, resourced projects. Next, they point to a hole created as heavy internal processes governing resource allocation stamps out opportunities for individual contributors to cultivate new and potentially valuable ideas. In some instances, they may elaborate on specific hurdles that stifle innovation within their organization. Examples of barriers described during our interviews include contradictory performance indicators between middle and upper management, annual budgeting processes, organizational focus on short-term financial results, and HR policy. Finally, they propose a Fab Lab as a credible solution to respond to this threat.

The second core threat identified relates to innovation as a vector for organizational transformation. It suggests that a Fab Lab is required to develop increased innovation capabilities to remain relevant in a competitive landscape. The underlying risk embodied by this threat is that of inaction or of insufficient action when faced with a continuously evolving market. Similar to an aircraft that stalls and eventually crashes, proponents of this threat suggest that their organizations must continuously improve their capabilities.

This second threat is typically introduced by recognizing competitive and economic pressures encountered by the organization, followed by recent examples of these challenges. Next, proponents may refer to trends observed in other sectors that do not yet impact the organization, but which could lead to increased pressure that would likely jeopardize the firm if they arrived. Common examples include the imminent risk of “uberization” or rumblings about a major technology company preparing to disrupt the precarious balance market. Finally, the Fab Lab is presented as a mechanism to stave off the effects of these external pressures by increasing the firm’s ability to innovate.

At first blush, both threats appear highly similar. They both focus on future events and avoiding the risk of missed opportunities. Despite these similarities, after further questioning the proponents of these threats, we identified a key ideological difference. The first threat focuses attention on a specific value-creation outcome; the second creates interest by developing skills needed to succeed in the future. Put differently, the first threat calls for “offensive” tactics, while the second builds upon a “defensive” strategy. In most instances, presentations we observed proposing the Fab Lab within an organization would portray both threats, with emphasis placed on one or the other. From our perspective, this underlines a complementary relationship between the two threats. Presenting a cohesive duo implies that the Fab Lab management idea offers a holistic approach to addressing multiple threats. In instances where one threat didn't appear credible to a member of the audience, the other one could still create a sense of legitimacy surrounding the management idea.

Throughout our study of actors found in large organizations, we observed an absence of critical responses challenging the validity or relevance of these threats. Not only did these threats resonate with individuals in our core research sample found in large firms,

it resurfaced during interactions with educators, public officials, and small-business owners. We consider this result an indicator of high levels of interpretability. Although tempting to conclude that these threats are universally interpretable based on these observations, we temper such conclusions. Our research was not intended to control for exogenous factors, such as peer pressure and cultural acceptability. By this we mean that it appears socially unacceptable to critique the value of innovation or the need to innovate under present conditions. At this stage, based on our observations, we can only make an informed assumption that the two threats described are generally applicable.

We now question whether Fab Labs are interpreted as an adequate response to both threats. We observed mixed reactions, largely dependent on the organization's size.

Most individuals associated with small and mid-sized businesses suggested that they were already able to find the resources they needed to develop new ideas within the organization if they so desired. In other words, they recognized the validity of the stated threats, but largely felt their smaller size provided a more flexible and adaptable organizational structure that neutralized their effects.

In large organizations, reactions to effectiveness of a lab in response to these threats differed substantially. The majority of the reactions we observed reflected generic enthusiasm followed by pointed skepticism. By this, we mean that most individuals we interviewed started with some statement recognizing that a lab could foster individual creativity and expression that could become valuable opportunities. However, in most interviews, these statements were soon followed by expressions of doubt.

For instance, in response to the first threat, even if employees have the resources to begin developing their ideas, what would make them want to stay with the company?

Why wouldn't they just use the lab's resources and then go elsewhere? Would the organization value their contributions? Similarly, we heard several individuals question the value of developing the innovation capabilities of individuals working in more operational roles, such as custodians, mechanics, and auditors. Others yet questioned the “completeness” of the Fab Labs in responding to this threat. Would the lab develop adequate capabilities to address the firm's systemic innovation needs, or is it just one small piece of a much bigger puzzle?

With regards to the second threat of organizational obsolescence necessitating transformation, we again found general enthusiasm followed by pointed skepticism. The technological apparatus of the Fab Lab management idea appears credible to initiate, materialize, and test new ideas. However, measuring the output of small-scale prototyping and conceptualization activities and measuring the transformation of capabilities at the scale of a large organization becomes problematic.

In one firm we studied, the CEO expressed initial interest in the Fab Lab management idea. However, he remained unconvinced that the Fab Lab alone could adequately respond to the threats conveyed. He invited the team proposing a lab to go back to the drawing board and develop a more robust solution that incorporated a lab component and responded to these threats. According to their management team, the activities of the larger program provided sufficient scale to measure changes in organizational capabilities. We observed in Article 2 that this specific lab demonstrated the highest levels of object output and subsequent product development in our study.

From these reactions, we gather that Fab Labs are not interpreted as an adequate, complete response either threat in large organizations. Notwithstanding, it appears

credible that labs contribute as part of a more comprehensive response to these threats. The scope of our current research remains insufficient to establish a causal relationship between the completeness of an organization's response to this threat and the effectiveness of its Fab Lab. However, our observations invite additional exploration to determine how the outputs of corporate Fab Labs are influenced by the existence of other elements intended to address these generally accepted threats.

Warrants

Warrants support a management idea's central claim by building a sense of credibility; they also suggest that a given idea is adequately able to address stated threats. Warrants can take multiple shapes, such as success stories, demonstrable trends, association with prestigious organizations, and endorsements. To be interpretable, they must appear credible and pertinent to the receiving parties. In this section we describe the primary warrants observed, the frequency and context in which they appeared, as well as the manner in which they were received as an indicator of interpretability.

Warrants supporting Fab Labs abound. We begin our exploration of warrants supporting the Fab Lab management idea by pointing to its origins. Fab Labs emerge from a prestigious academic institution: MIT. The use of this warrant appeared in all organizations we studied, but its purpose was limited to explaining the origins of the management idea. In practice, we never observed anyone question the validity of using MIT as a warrant, suggesting that it carried some meaning to observers. This indicates interpretability. However, we always observed conversations mentioning MIT gravitate towards additional supporting warrants. This suggests that this warrant, while meaningful, is insufficient to independently support the management idea.

In a similar fashion, we observed proponents of the Fab Lab management idea point to hundreds of large municipalities and small towns who quickly adopted Fab Labs and labeled themselves “Fab Cities” (Diez, 2012). In addition, they often alluded to the outcomes enabled by Fab Labs envisioned by local leaders, such as reduced unemployment, increased sustainability, and connectivity to a global knowledge network (Gershenfeld, 2015). These were all portrayed as potential benefits of establishing a corporate Fab Lab. Although these individual benefits are quite specific and less interpretable under certain conditions, they were always presented collectively. A sense of generality and interpretability emerges as this collection implicitly reflects ways for an organization or community to create value. Similar to the MIT warrant, we always observed conversations mentioning these outcomes include additional supporting warrants. Again, while meaningful, this warrant appeared insufficient to fully support the management idea.

We determined that the most compelling, interpretable types of warrants were those that that could stand as a lone argument in support of a proposal. We observed this behavior when individuals in large companies pointed towards their peers and competitors creating their own labs as justification for creating or using a Fab Lab. In nearly all instances, this warrant provoked a visible reaction of increased interest and attention: eyes glued to laptop screens in conference rooms immediately looked up to the presenter. Looks became more focused. Questions zeroed in on other companies' practices.

Interestingly, this warrant is neither general nor ambiguous; instead, it is quite specific. This contradicts the typical conditions of interpretability. One could argue that interpretability exists in situations where the management idea's proponents point to

multiple organizations with similar characteristics that have already adopted the management idea. This builds an interpretable form of credibility: if the management idea works for others, it might work for us.

On the opposite spectrum of interpretability, we observed a case where executive-level support in favor of a lab immediately emerged in response to this warrant. They stated they wanted to neutralize a competitor's potential advantage. We question whether this situation deviates meaning of a warrant. Instead, it appears the management team implicitly interpreted the competitor's actions as both a warrant and a threat. While this transformation from warrant to threat intrigued us, we recognize that both warrants and threats ultimately support a management idea's central claims. For the purposes of our research, we assume this dynamic has no meaningful effect on the management idea, but this question stands open to continued research.

Despite the fact that most warrants supporting the Fab Lab management idea referred to specific examples, these examples were meaningful enough to elicit reactions in most situations we observed. As such, we consider the warrants observed sufficiently interpretable in the context of large organizations.

Discussion of rhetorical elements

From a broad perspective, the rhetorical elements embodied by the Fab Lab management idea appear sufficiently interpretable in the context of a large organization. The Fab Lab label is short and meaningful. The management idea's central claim of fostering innovation capabilities is generally appealing and socially acceptable. The threats and warrants supporting the central claim appear significant. Each of these four rhetorical elements were sufficiently interpretable to enable the diffusion,

interpretation, and implementation of the Fab Lab management idea beyond the extent that we observed.

Notwithstanding, our analysis of the central claim, threats, and warrants highlighted some important limits we'd like to attempt to resolve in the next chapter. The central claim made in support Fab Labs is overly extensive; the solution embodied by the management idea cannot reasonably be considered a comprehensive solution in a large organization. Similarly, threats used in support of this central claim are considered generally valid but fail to convince that a lab is the ideal or exclusive solution to mitigate that risk. Warrants took on multiple shapes, including a prestigious pedigree and growth trends. Despite this, the most effective warrant observed in terms of time required to gain executive leader support—a competitor creating a lab—appeared to be a shapeshifter. Instead of acting as a warrant, it took on the appearance of a threat.

From our analysis and empirical observations, we consider the Fab Lab management idea's rhetorical composition particularly effective at grabbing attention and stimulating action. The existence of labs in multiple organizations attests to the effectiveness of persuading an organization to embrace this management idea. Despite this action, we observed that these broad arguments set expectations a Fab Lab alone cannot reasonably meet. This approach of over-promising and under-delivering can undermine credibility. Although this practice facilitates initial diffusion, we ultimately believe this behavior could act as a disservice to the reputation of corporate Fab Labs long-term.

Resolving this dilemma would involve a significant adjustment to rhetorical claims. Instead of capitalizing on issues applicable in any competitive environment, it would focus on the specific value propositions labs introduce in a corporate setting. As such,

the scope of the central claim and its supporting threats and warrants would become more focused. In order to explore this avenue, we must first dissect the technological elements of the management idea: what Fab Labs do and how they do it. This analysis is presented in the next section. In the following chapter, we attempt to align the scope of rhetorical arguments based on a lab's unique technological elements. In other words, we propose a set of rhetorical arguments founded upon our empirical data of what a lab actually does. As a result, we could then appropriately describe why and when an organization would need a lab.

Technological elements of the Fab Lab management idea

The technological aspect of the Fab Lab management idea conveys what and how a lab should respond the promises made by the rhetorical aspects studied in the previous section. Our analysis in this section details the current state of what Fab Labs do and how they do it. High levels of interpretability are determined based on use patterns found in multiple organizations. Technology in a management idea is conveyed through four distinct bodies: principles, practices, techniques, and implementation guidelines (Rauth, 2015).

The first three technological elements—principles, practices, and techniques—are inter-related and sit in a hierarchical order. Principles are composed of practices; practices are composed of techniques. Principles sit at the highest level of generality. They describe a set of overarching ideals the management idea should put into practice, such as “fail fast, fail cheap, fail often.” Practices sit in the middle. They represent a category of techniques that enable the pursuit of those principles. For instance, practices like “ideation” and “rapid prototyping” support the principle “fail fast, fail cheap, fail often.”

Techniques—which sit at the lowest level of generality—thus describe how one can pursue a given practice. For instance, one can use techniques like brainstorming, focus groups, world cafés, user research (ethnography), or innovative design workshops to support the “ideation” practice and its overarching principle. Based on this hierarchical relationship, we expect principles to be highly interpretable while techniques may be less interpretable.

The fourth technological element—implementation guidelines—constitutes a set of accepted practices a lab creator typically follows as they create a Fab Lab. To be effective, these principles must be sufficiently interpretable so that they can be followed in a wide range of organizational settings.

Principles

Principles found in our empirical data, such as “fail fast, fail cheap, fail often,” and think outside the box are both ambiguous and general. In our observations, principles used by labs were typically expressed in the English language, even in contexts with different local working languages. Despite the fact that many employees are capable communicators in English, the use of a non-native language can further increase ambiguity because it introduces multiple potential interpretations. For instance, we can look at a common principle we encountered based on an idiomatic expression: “think outside the box.” The French word for box is “*boîte*,” but the sense of this expression would more appropriately be translated as “quitter le cadre” or to leave a frame or bounds. A “*boîte*” is also a common informal expression in French that refers to a company. Thanks to these multiple interpretations, ambiguity increases. In the mind of a Francophone, this principle could strongly suggest thinking outside the company, or

within the company but working outside its' standard processes. Many principles were interpreted as a type of mindset one should find in a lab, a notion we developed in detail in Article 1.

Practices

Practices begin adding substance to principles and could be described as a discipline or general approach to act upon principles. While we observed substantial diversity in the interpretation of principles, we observed that an increasingly homogeneous set of practices emerged across labs. The two most commonly identified practices were fostering creativity and rapid prototyping. These practices could be associated with many principles, which appeared frequently. The existence of these many-to-many relationships between principles and practices suggest high levels of ambiguity. We also occasionally observed the presence of organizational emphasis on specific practices: one firm had developed its own form of practice for product design and its Fab Lab acted as a tool to support that unique design practice. Although these individual practices were quite specific, outside observers recognized them as a type of “special sauce” that relies upon a specific organizational culture. As such, most Fab Lab managers we observed determined they could safely leave these practices out of their own Fab Lab and complement them with practices better suited to their form. In this situation, we consider that the generality of the management idea is preserved. We also consider that these situations increase ambiguity since they reinforce the idea that labs can be made from a loose set of practices.

Techniques

Techniques are methods used as part of a general practice. Given the general characteristics of methods that include standard processes, we naturally assumed techniques would be less interpretable. This was true of certain techniques, in most cases those related to operating certain types of machinery or software. In France, a consortium of corporate lab managers came together as a group to share these types of techniques, including documentation, software hacks to improve machine performance, or raw materials sourcing tips. However other techniques opened the door to substantial interpretability, such as performing a brainstorming workshop, organizing an open design challenge, or selecting content to share with the internal corporate communications department. One could argue that this latter group of techniques involves variable outcomes (e.g., a design challenge could produce no exciting ideas from a management team's perspective), whereas the former group of techniques aims to produce a specific type of outcome. In both situations, we consider that interpretability is preserved in different ways.

Regarding the first set of techniques that result in specific, reproducible outcomes, ambiguity is eliminated to ensure a consistent result. However, generality is maintained because a lab may or may not require those specific outcomes or techniques. For example, we observed a Fab Lab that had a multi-million-dollar budget to provide project seed funding for innovative projects. This lab had a specific project funding technique, but the use of this technique doesn't apply to labs without a similar early-stage investment budget. In addition, a variety of techniques producing similar outcomes typically exists, which ultimately increases generality.

Concerning the second set of techniques that produce variable outcomes, we consider that both ambiguity and generality are maintained. Ambiguity is introduced due to the variable nature of potential outcomes; what works in one organization or department at one point in time may not be repeatable or desirable. Generality is also maintained for the same reasons previously described in relation to techniques with given outcomes.

Implementation guidelines

The fourth element of technology carried by management ideas includes implementation guidelines. Interestingly, we found very few formal guidelines. One notable exception includes MIT's sample inventory of machines they sourced to create their labs, which is simply described as a potential starting point. In our empirical data, we found no examples of formal guidelines employed to create a lab. Instead, most lab creators patterned their own actions after observing what peers in other companies had already done. This result introduces suggests that Fab Labs benefit from intuitive interpretability: one can see a Fab Lab and mimic it within their own organization. We analyze this result in our general discussion of technology elements below.

Discussion of technological elements

Each of the individual technological elements associated with Fab Labs display high levels of interpretability within a large corporate environment based on empirical data. This pattern is consistent with most effective management ideas. However, upon completing and reviewing our analysis, we realized that the primary sources for principles, practices, techniques, and implementation guidelines were developed within Fab Labs themselves. This result stands in contrast with most management ideas, where the technological elements are formalized in external sources, including professional &

academic literature. This apparent difference leads us to consider the role played by these external sources in relation to most management ideas, and then consider how these roles are fulfilled in relation to the Fab Lab management idea.

The diffusion of most management ideas is heavily supported by external change agents who theorize a body of principles, practices, and techniques (Birkinshaw et al., 2008). This role is typically played by “management intellectuals” (ibid.) such as academics and management consultants who base their work on various observations and experimentation (Kaplan, 1998). As they theorize their findings, these agents build a “package” (Czarniawska & Joerges, 1995) containing definitions and descriptions of a management idea's required technological elements.

This dominant pattern of theorization by external change agents is followed by diffusion. These external agents employ an extensive infrastructure, including speaking engagements, writing management books, newspaper columns, and scientific articles. These agents often develop their perspective by interacting with the management idea in a wide variety of settings through professional consulting engagements (Kaplan, 1998). This visibility provides external agents with additional opportunities to implement and test the management idea's technological package. Through experimentation and practice, the sophistication of the package increases.

Examples of this packaging & diffusion pattern abound, such as Drucker's work on Management by Objectives (MBO) that stemmed from the *manager's letter* practice observed at GE. Drucker theorized and extended the practice as MBO before introducing it to other areas of GE, followed by General Motors and others (Drucker, 1978). Similar

patterns are found in the management ideas identified earlier in this chapter; we do not expand upon them further.

In comparison to this common pattern, we find that few—if any—external agents have packaged the Fab Lab management idea. In our experience, this package is typically formulated by the internal change agents who propose, implement, and manage labs through a mechanism that at first blush shares some similarities to the field of research of strategy-as-practice (Dameron, Lê, & LeBaron, 2015). Instead of referring to books and presentations by management intellectuals, the formal “package” of the Fab Lab management idea is typically found in a handful of PowerPoint slides. This comparison of David-versus-Goliath proportions leads us consider what differences would enable the Fab Lab “package” to circulate and diffuse with significantly less influence by outside change agents compared to other management ideas.

We recall that the theorization a management idea acts to increase the “zone of acceptance” for a set of practices (Rao, Monin, & Durand, 2003) by formulating a condensed, abstract, interpretable view of them. Theory-building creates a bite-sized view of an extensive—and otherwise unapproachable—set of actors, relationships, practices, and techniques.

In contrast to most management ideas, a Fab Lab is a self-contained, tangible entity. One can visit the lab, watch what's going on, and see how it works. An observer can realistically experience the Fab Lab management idea during a single visit. We believed the pre-packaged appearance of Fab Labs might enable the theorization process to occur at a different level without the typical involvement of management intellectuals.

We quickly tested this dynamic during our empirical study: during our observations of corporate labs, we encountered various individuals working for outside companies who stopped through to visit the lab, typically after learning about it through word-of-mouth. Following their visit, we briefly invited them to summarize what they observed in the lab, and then categorized their responses based on principles, practices, and techniques. We then asked them if they thought a lab would be useful in their company and conceptualize what it could look like in their company. Finally, we asked them how confident they would be presenting the case to their company's management team based on what they observed. In seven separate instances, the visitors interviewed had never heard of Fab Labs prior to visiting the lab. Following their respective visits, all seven of them could provide a synthetic description of the lab, how they thought it would be useful in their workplace, and described what changes they might introduce to make it applicable to their company's needs. These reactions suggest that the theorization of Fab Labs can occur on an individual level, a natural consequence of the apparent simplicity of the labs. We identified a similar pattern of individual theorization in nearly all accounts of individuals proposing and creating a lab in our empirical data.

By reducing the barriers of entry needed to theorize a Fab Lab, any individual can develop their own packaged form of this management idea. As such, we expect a high degree of variation in the package. We make a distinction between the packaging, which reflects rhetoric, and the contents of the package which represent the technological components required to fulfill the rhetorical promises.

In the previous section, we demonstrated that the packaging—rhetoric—remains relatively consistent: labs are packaged as a solution to enhance an organization's ability to innovate. While the outer rhetorical package appeared stable, we observed in practice

that the package's contents—technology—appeared to vary between individual interpretations and each organization's implementation.

We wanted to determine whether any consistent patterns regarding “fundamental” or “essential” principles, practices, and techniques associated with a Fab Lab. To do this, we asked individuals considering creating a lab in their organization to describe the essential elements their lab needed to offer. Based on our experience and intuition, we anticipated responses would consistently refer to digital fabrication machines, prototyping, creativity methods, paired with the principles of openness or bridging organizational silos. While some responses contained these elements, to our surprise, the responses were heterogeneous. For instance, one manager thought her lab should solely provide a small collection of hand tools for tinkering; another thought it should feature a nap corner and hammocks to help creative juices flow; another suggested it should have a display case that promotes examples of employee creativity. Some employees advocated the lab should be used exclusively by special project teams working on 90-day product development sprints.

In order to control for differences between the firms we observed, such as industry, business model, and corporate culture, we compared responses from multiple individuals working for the same firms. Even within the same firms, divergent ideas were common, although homogeneity in responses amongst individuals working together as a team to establish a lab.

Due to the ease of intuitive, individual interpretation of the Fab Lab management idea, it appears Fab Labs are not only a place to “make (almost) anything,” (Gershenfeld, 2005),

but also a place that can be made from (almost) anything. As such, we are confident that the technological aspects of the management idea reflect high levels of interpretability.

From our perspective and observations, a management idea based primarily on individual interpretations introduces additional managerial considerations. The individuals creating a Fab Lab should recognize that the absence of theorization by external change agents carries both virtuous and negative consequences. Instead of building upon a foundational definition of a lab's technological aspects established by an external change agent, each lab creator must define their own principles, practices, and techniques. This provides unlimited latitude to create a highly-adapted solution for an organization. We observed this benefit comes at an additional cost: a large portion of work performed to design a lab's technological components appears redundant. In addition, self-constructed definitions also lose the benefit of increased legitimacy provided by external change agents who have already validated their work. In conclusion, we believe some level of external theorization may be useful to practitioners.

The limits of Fab Labs interpretability & potential solutions

Given the highly interpretable characteristics of both rhetorical and technological dimensions surrounding Fab Labs, we inductively determine that it is a management idea. Our analysis suggests that challenges exist with regards to the interpretability of central claims. We address this challenge specifically in the following chapter by proposing alternative claims with a narrower scope based on empirical observations. Our result of qualifying corporate Fab Labs as a management idea carries three important managerial considerations.

First, the nature of Fab Labs as a highly interpretable management idea explains significant variations and differences observed between labs—especially those found within the same cultures and organizations. As each department or company creates their own Fab Lab, a group of individuals interprets this management idea, and the resulting environment reflects their interpretations. This presents a challenge for those who wish to positively identify what a Fab Lab is or is not in a corporate environment. As a management idea, one recognizes that implementation remains subject to individual interpretations.

Second, the effects of individual interpretation are amplified as Fab Labs are positioned as a silver bullet in relation to overly broad central claims (i.e., enable a company to innovate). This claim invites nearly any initiative that enhances innovation capabilities to identify themselves as a Fab Lab. Similarly, managers may already consider that they already have a Fab Lab based on existing efforts to enhance innovation capabilities found in the firm. This outcome occurred in two firms that participated in our study. Based on this finding, managers should carefully consider whether the use of these claims ultimately benefit their efforts. In the following section, we develop and propose a more specific central claim in the following section.

Our final managerial consideration based on this takes a step back from the composition of the Fab Lab management idea. We simply ask: do Fab Labs reflect a passing management fad or an evolving management fashion (Abrahamson, 1996)? The surge of new Fab Labs in corporate settings directly observed between late 2013 and late 2016 suggests the Fab Lab management idea garnered significant attention. During this time period, we identified over 50 large multi-national firms who created their own Fab Labs. These behaviors reflecting infectious diffusion indicate a degree of fashionability. Since

2016, existing initiatives continue to develop and grow at a slower pace; in most instances the Lab doesn't expand its initial size and scope. At present, new initiatives are a rare oddity. In addition, we are aware of a handful of lab creation projects that were deprioritized and cancelled as decision makers heard of inconclusive results from their peers at other firms with labs. In other words, the Lab did not fulfill the promises of its central claim, or at least in a way understood by executive leaders.

These recent data points appear indicative of a passing fad. In reality, it remains too early to ascertain whether the stagnating adoption of the Fab Lab management idea reflects a bygone fad or presents an opportunity for a stage of restructuring and increased fashion. In the former case, we would reasonably expect Fab Labs to disappear over coming years. This outcome feels unfortunate yet predictable. We consider it unfortunate because most labs reflect employee-driven initiatives to support management's goal of enhancing their firm's ability to innovate. At the same time, we find this situation predictable as these initiatives espouse overly interpretable elements of rhetoric and technology. Again, we believe that restructuring this management idea to embody a more mature, specific central claim could lead to a renaissance of this management idea. As such, we would anticipate that the firms that embrace a more focused central claim would benefit by being able to accurately identify and measure the contributions they make to a firm's ability to grow and transform through innovation. If effective, we would expect labs to continue to grow and adapt in order to respond to a broader set of organizational needs.

Chapter 7: Enhancing the central claim for corporate Fab Labs

In the previous chapter, we qualified Fab Labs as a management idea and explored the idea's underlying theorization (Birkinshaw et al., 2008) through the prism of rhetorical and technological elements. Most of the individual properties underlying this management idea's rhetoric and technology appeared highly interpretable. In other words, the elements conveyed by Fab Labs are sufficiently general and ambiguous for others to apply them in various organizational settings. However, our analysis also revealed a critical shortcoming in the existing rhetorical theorization of labs. Specifically, we identified considerable doubt regarding the credibility of a Fab Lab's broad central claim, its ability to adequately respond to the claim's associated threats, and the validity of warrants due to heterogeneous practices & techniques.

In this chapter, we attempt to contribute to the theorization of the Fab Lab management idea by developing a more specific yet interpretable central claim that reflects empirical observations. Based on our analysis in the previous chapter, we maintain that labs are indeed intended to enhance innovation capabilities. However we want to refine this broad claim to align with the underlying technology of the management idea—in other words **how** labs improve a firm's ability to innovate. To do this, we start by identifying specific differences in how a lab operates compared to other areas of the companies we observed. We then analyze these differences and reformulate them as a proposed central claim. We conclude by discussing and exploring the properties and implications of this claim in detail.

Key differences observed in Fab Labs

The ability to innovate fundamentally stems from the ability to do things differently. Adopting different approaches does not exclusively result in an innovative outcome: for instance, changing the order in which dry ingredients are added to a cake batter will not change the end result. Notwithstanding, change remains a crucial supporting ingredient to enable innovation. At the outset of our analysis, we consider that any situation that enables members of an organization to behave differently is a potential vector for innovation capabilities. As such, we want to identify patterns present in corporate Fab Lab environments by observing interactions and activities that result in doing things differently. When comparing behavior between labs and the broader corporate organization, the following four differences observed caught our attention. The order in which we list these patterns bears no significance.

N° 1: Fab Labs eliminate or modify common divisions of labor

In Fab Labs, engineers handled physical materials in addition to designing computer-generated models, while technicians continued using tools and learned to perform their own computer-assisted design work. Standard operations in all companies studied promote clear division of labor, separating engineering and design tasks from technician-performed production tasks.

N° 2: Fab Labs blur institutional notions of expertise

In a lab, an individual's formal qualifications or hierarchical position often carry little weight. Instead, the ability to “do” or even the willingness to make an earnest attempt and try becomes significant. Other disciplines have qualified this dynamic in similar

contexts as a “do-ocracy ethos” (D. W. E. Allen, 2017; Lallement, 2015). Standard operations in all companies studied have clearly defined roles reserved to a limited pool of “experts.”

N° 3: Fab Labs erase several effects of bureaucracy

All corporate labs studied provided resources and materials to employees with few or no formalities. For instance, an employee could come to a Lab and leave with an object she created herself. She could do this without receiving a design approval, generating a purchase order and budget allocation request, obtaining management approval for the purchase, waiting for a long production turnaround, or risk internal mail services losing the parcel containing the requested part. In short, standard operations in most companies studied involved several of the above-mentioned, time-intensive, bureaucratic processes. This effect of reducing bureaucracy appears temporary and limited in scope.

N° 4: Fab Labs enable individual expression

Projects undertaken in labs typically reflect taking initiative, whether performed individually or as a team. Activities are neither assigned nor compulsory. In contrast, standard operations in most companies revolve around assignments given by rank-and-file leadership.

We note that these statements reflect general patterns and trends observed in labs. These comments do not reflect a set of proprietary solutions offered by the Fab Lab, nor does it judge the effectiveness of the lab in obtaining these outcomes. In spite of these apparent shortcomings, we recall that the ultimate objective of this analysis is to

contribute to the “theorization” (Birkinshaw et al., 2008) of the Fab Lab management idea by identifying a more robust central rhetorical claim. This objective requires a dimension of interpretability that accommodates high degrees of generality and ambiguity to the extent that they appear plausible. As such, the existence of competing solutions and situations when a given lab doesn’t provide one of these outcomes should not adversely impact our analysis.

In addition, we draw specific attention to an aspect that many individuals explicitly mentioned during our observations as a critical differentiator between labs and organizations. For most of these people, working in the lab represented the first opportunity they had to use tools and machines to create physical models in the workplace. These individuals typically produce digital models and representations as part of a design workflow; they rarely interact with tangible models of their designs. We find this to be a natural consequence of the division of labor previously mentioned: most employee roles are not involved in creating physical prototypes. However, we found that nearly all companies we observed *do* engage in some form of physical prototyping at a later stage of the design process in order to validate the digital design work performed. While the ability to produce a physical model to validate one's own work appears significant to the employees who did not previously work with tools, the organization already performs this function at some point. As such, we do not consider it a distinct difference between the lab and the organization.

Among our four identified differentiating patterns, we identify a common, unifying property. Each of these four differences represents activities made possible because the lab acts as a self-contained environment. In other words, lab activities remain mostly independent of the organization's ongoing operations. Due to this characteristic, we

consider that the effect of the differences found in labs is somewhat temporary. Once an individual leaves the lab and returns to their day-to-day responsibilities, the temporal limits of this environment reappear: division of labor, expertise, bureaucracy, and individual expression revert to the organization's norms. At a high level, this suggests that labs introduce an alternate, self-contained working environment that promotes innovation.

We recall that our analysis intends to identify what Fab Labs uniquely provide an organization in order to formulate an enhanced central claim. At first blush, the ability to induce a temporary shift in a working environment in order to generate innovation capabilities appears compelling. However, this claim is not fundamentally unique to corporate Fab Labs. In some of the organizations we studied, we also observed managers achieving similar outcomes through alternate means. For instance, they do this by organizing offsite creativity sessions, engaging special cross-disciplinary working groups, or even partnering with local coworking spaces to increase exposure to diverse individuals. Many of these methods existed before creating a Fab Lab. This suggests that a central claim based on providing an isolated environment for innovation is insufficient to qualify the contributions of a Fab Lab as something unique.

It was not immediately evident how we might resolve the tension between the claims formulated by the individuals we interacted with in Fab Labs and the apparent absence of these different spaces making a unique organizational contribution. While reflecting on this challenge, we pursued other avenues of our research, enabling us to continue observing and understanding lab dynamics. One day, we observed a division executive working in the firm's engineering department come into the lab for the first time. After a brief tour of the space, he opened his laptop on a couch and began drawing a digital

model of a simple object for his desk. As he watched the plastic filament from the 3D printer slowly build his design, he quipped: “Wow, I can’t believe I’m actually able to do this here. Executives never have any fun! I can’t draw models or make some farfetched contraption anymore. This takes me back to how I used to work when I was started my job after engineering school.”

This seemingly offhand remark sparked a thought exercise on our part: did the apparently isolated environment of Fab Labs enable a change in organizational state? Specifically—based on this executive's comment and paired with our finding in the previous chapter that labs are frequently named after events or settings that were significant in the organization’s history —does a corporate Fab Lab emulate an organization's prior state?

Our four differences presented earlier in this section and observed in Fab Labs each suggests various forms of simplification occur. In the above comparisons between lab operations and the firm's general operations, we observed multiple forms of organizational simplification. Within the lab space, the effects of hierarchy, bureaucracy, labor division, and conformity temporarily dissolved. We recall that these institutions exist as a means of managing complexity; these four notions make little sense in smaller organizations.

The environmental conditions generated by Fab Labs appear to provide an antidote to the effects of operating at a large scale: the lab reverts a small part of the firm to a simplified structure. Within a lab, an organization is reduced to its embryonic state. Within this space, innovation emerges from the most basic operating environment. This environment enabled the previously mentioned executive to temporarily return to the

type of work he performed at the beginning of his career. As we reviewed our empirical data, we identified a similar effect on individuals who actively participated in lab activities. We call this primary function a “reset.”

In the following sections, we will introduce and explore the notion of a reset based on the word's formal definition. We build on this technical definition to determine how resets operate. We then validate whether Fab Labs can appropriately claim to enable innovation through organizational resets by analyzing our empirical data to identify the presence of resets in practice. Finally, based on our analysis, we determine whether it is appropriate to propose resets as a more specific central claim to support the Fab Lab management idea.

Qualifying resets

During our field research, we found the “reset” expression particularly useful in discussions with practitioners as it reflected the idea that Fab Labs could do accomplish something fundamentally different to help their organization innovate. We want to evaluate whether this pragmatically ambiguous phrase (Giroux, 2006) used during our research—“resetting innovation capabilities”—could theoretically stand as a viable central claim for the Fab Lab management idea. As such, we want to explore the notion of resets in some detail. We start by establishing a technical definition, followed by a more pragmatic analysis.

The word reset refers to a specific action upon a given object, as defined by three authoritative English dictionaries: “*set again or differently*” (Oxford English Dictionary,

2010). “to set again or anew” (Merriam Webster, n.d.) “To set again; To change the reading of; To adjust” (American Heritage Dictionary, n.d.)

These definitions feel intuitively familiar in relation to management research. The ability to set an organization differently anew or differently suggests that elements of resets are apparent in management literature reflecting organizational change. However, the term “reset” isn't specifically present in existing management research as an established notion. Given its utility during our field research, we believe an analysis of the word “reset” may introduce additional concepts or perspectives.

A reset action is narrow in scope: by definition, a reset requires an element of change to take place. However, this definition is also expansive as it does not prescribe what is being changed and the significance or frequency of the change. As such, correctly identifying a reset requires one to precisely identify an object upon which a reset can be performed. We denominate the object being reset as “A.” By definition, to perform a reset, one merely needs to reconfigure A in some way that is not A.

The number of modifications available to describe an object that is “not A” is theoretically infinite: it includes everything except object “A” itself. The specific criteria that a reset object must not be “A” acts as a lone counterweight to the otherwise unbounded field of possibilities. We can express the ratio of specificity (“A”) and ambiguity (“not A”) in these terms: $1:\infty$. Due to limitless possibilities, resets can be simply expressed as a source of knowledge expansion, which can ultimately lead to innovation under the right conditions.

The absence of theoretical constraints in the notion “reset”—requiring the “right conditions” that can result in innovation—hinders this notion’s utility from a

management perspective: firms live in a realm of finite constraints and bounds. As such, we logically want to include an additional parameter in our definition of resets that transforms an infinite field of possibilities to something usefully finite. We do this by introducing general criteria of desirability (Hatchuel, Starkey, Tempest, & Le Masson, 2013). In other words, one should only perform a reset if they believe it could potentially produce a desirable outcome.

By introducing this desirability condition, we hold that a reset should produce something that is “not A, yet desirable.” Expressed using the formal definition's original terms in addition to our constraints for organizational utility, we determine that resets represent the following:

“Set an object again or differently to produce something desirable.”

From our perspective, the condition of desirability is implicit in the original definitions. Nonetheless, after making this notion explicit, we want to ensure that interpretability is maintained with our addition for the purposes of enhancing the central claim of the Fab Lab management idea. This formulation does not limit the nature of objects subjected to a reset, maintaining generality. Our desirability constraint reduces ambiguity by introducing a specific condition. However, qualifying desirability remains an inherently subjective task based on individual or organizational criteria to determine value. This condition creates different meaning from one situation to another, suggesting that ambiguity and interpretability are both maintained.

Identifying properties of resets

Now that we've described resets, we want to identify the types of actions they perform to produce desirable outcomes. To accomplish this, we analyzed the twenty example sentences for the word “reset” contained in the Oxford English Dictionary. We assume that these examples reflect actions intended to produce desirable outcomes from the perspective of a single actor.

In each of the twenty example phrases provided by the dictionary, we identified three key properties of the reset action: the object being reset, the modification performed by the reset, and the elements required to perform that modification. We then compare these properties to identify and discuss common types of resets.

Sample analysis of a sentence: “The child should set the alarm before bed and reset the alarm if it goes off.” (Oxford English Dictionary, 2010)

In this example, the object being reset is an alarm clock. The modification performed was resetting the alarm to its prior state to go off the next day. No additional elements were added to the alarm clock in order to perform the reset action.

In our analysis of the twenty example sentences, all of the objects being reset were different. As such, we couldn't identify a consistent reset pattern based solely on the objects being reset. Instead, we looked to the two other properties found in these example sentences to identify patterns:

1. the modification performed by the reset action
2. the elements required to perform that modification

Within both of these properties, we found consistent patterns. In the first property—the modification performed—we found that either the object being reset was either returned to a prior state or resulted in the creation of a new state. The second property—the elements required to perform the modification—were found to either exclusively reuse existing elements or introduce additional elements in order to perform the reset. The patterns identified for these two properties appear mutually exclusive, yet exhaustive in scope.

Further analysis of the example sentences suggests that there is no implicit co-dependency between these two properties. For instance, returning to a prior state may require the introduction of new elements, such as clubs that make costumes from synthetic materials to re-enact medieval settings. Similarly, a completely new environment could be created by repurposing existing elements, like transforming discarded lychee pits and mango seeds into a game. As such, we propose the following basic reset framework (Table 7–1) based on the sample use phrases found in the Oxford English Dictionary.

Table 7–1. Theoretical reset framework

	Reset performed by using existing elements	Reset performed by introducing new elements	TOTAL
Reset to an object's prior state	12/20 sample use phrases (60%)	2/20 sample use phrases (10%)	14 of 20 (70%)
Reset an object to a new state	5/20 sample use phrases (25%)	1/20 sample use phrases (5%)	6 of 20 (30%)
TOTAL	17 of 20 (85%)	3 of 20 (15%)	20 total use phrases (100%)

As an initial observation, we remark that the term reset is most commonly used in reference to actions that result in creating a prior or pre-existing state, predominately through the use of existing elements. Resets that result in the creation of a new state or that introduce new elements are far less common. Due to the mutually exclusive nature of the dimensions in our proposed reset framework, we want to determine whether each of these resets results in different outcomes by exploring how each of the four types of reset operates. We accomplish this by illustrating each quadrant of the matrix through an analysis of four representative phrases using the word “reset” drawn from the Oxford English Dictionary.

Reset n° 1: reset an object to its prior state using existing elements

Sample use phrase: *“Reset an alarm clock after it goes off.”*

Frequency: 12 use phrases out of 20 (60%)

The most frequent type of reset refers to an object that is restored to a previous state. We noticed that most of the example sentences described resetting ordinary objects that one would expect to frequently reset as part of the object's normal use. The example phrase describes a common situation: the clock with a buzzing alarm is returned to a prior, non-buzzing state. In this previous state, the alarm stands ready to buzz again at a designated time.

In all of these example sentences, we found some exogenous event took place which triggered the need to reset the object. The various triggers identified in the twelve example phrases referred to: resetting alarm clocks & timers (time-triggered), environmental condition alarms (temperature or humidity-triggered), burglar security alarms (motion-triggered), and a mobile phone ringer (situational etiquette-triggered).

For convenience, we refer to this type of reset as a “trigger reset” since an outside event triggers the reset action.

In all of the above situations, the desirability of the trigger reset comes from generating some alert or interruption when a specific event takes place. The intent of these notifications is generally to provoke some action. In the case of the triggers identified in the example sentences, these actions respectively involve getting out of bed, taking a dish out of the oven, repairing heating or cooling equipment, calling law enforcement, or avoiding undesired interruptions. As such, we consider that trigger resets are intended to result in repeated, near-immediate actions.

Reset n° 2: reset an object to its prior state using new elements

Sample use phrase: *“The thigh failed to mend properly and had to be reset.”*

Frequency: 5 use phrases out of 20 (25%)

In some situations, obtaining a prior state requires the use or introduction of additional elements. For instance, the process of resetting a thigh to its previous, operational state might require the introduction of medical interventions (surgery & subsequent physical therapy) in addition to various physical artefacts (splints & crutches). In all likelihood, the reset action from this example will remain partial. While the bone's functionality might be restored, the healed bone will always reflect some form of prior trauma and structural weakness.

Among the twenty example phrases in the Oxford dictionary, five described resets that return an object to a prior state by introducing new elements. These actions took place in order to reset the effects of broken bones, drifting machine calibrations, or a historic

site that fell into disrepair. Based on these examples that restore some desirable aspect of a prior state, we refer to this type of reset action as a “restorative reset.”

Reset n° 3: Resetting objects to a new state with existing elements

Sample use phrase:

“We have to reset the terms of the debate and the way we use our power.”

Frequency: 2 use phrases out of 20 (10%)

In this example, two objects are being reset: the debate terms and the way power is used. Additional contextual elements are not provided, which increases the potential interpretations. We understand “reset[ing] the terms of the debate” stands as an invitation to reintroduce some formerly present values or rules of engagement in a debate. Similarly, the suggestion to alter the way power is used may call for the re-introduction of bygone standards and traditions. Although these values or rules existed previously, the reset state is fundamentally new. An example of this might be resetting a nation's government after a period of war and martial law.

Among the twenty example phrases in the Oxford dictionary, only two described resets that create a new state from existing elements. The second example phrase identified refers to creating a new legal landscape based on an existing element: precedent. From our standpoint, the two example sentences implicitly refer to traditions or established practices or going “back to basics.” We refer to this type of reset as a “fundamental reset” because they recall foundational aspects of the object being reset.

Reset n° 4: Resetting objects to a new state with new elements

Sample use phrase: *“The royal family often resets jewels and updates old pieces as fashions and owners change.”*

Frequency: 1 use phrases out of 20 (5%)

In this example, the object being reset are the Crown Jewels. The reset performed takes old jewels and places them into a new environment based on new fashions and the taste of new owners.

Although the original object being reset is not required to change, its' introduction into a new environment requires providing additional elements. Similar patterns are found in materials that are recycled, in individuals who expatriate to a foreign country, or in borrowing a best practice from one industry and introducing it in an entirely different context. We refer to this type of reset as a “metamorphic reset” because they transform the state of the object being reset in some substantial way.

Discussion of the four reset types

Resets that restore objects to a previous state appear most common in the example phrases, either through trigger resets that use pre-existing elements or restorative resets that introduce new elements. We note some key differences between the two actions.

Trigger resets (type n° 1) are generally intended to occur throughout the normal use of an object. These types of resets appear instrumental in preventing or diminishing the effects of an undesirable event, such as deterring burglars, preventing pipes from freezing in a building, or missing an important appointment due to oversleeping. As such, we see trigger resets as a way to encourage an intentional, specific behavior. This

degree of specificity appears somewhat incompatible in support of a management idea, since these triggers are not designed to result in high levels of interpretability.

In comparison to ordinary trigger resets, restorative resets (type n° 2) take place under somewhat exceptional situations that necessitate returning to a prior state with the help of some additional elements. Returning to a pre-existing state is possible in some common settings, such as resetting a machine with drifting calibrations. However, we believe that the window of opportunity to perform a restorative reset remains practically limited and time-sensitive. For instance, it'd be ideal to reset the calibrations of a tile saw before or after starting a flooring project to ensure consistent results. Altering the machine in the middle of a flooring project could produce inconsistent results. In a more complex example, changes to labor, environment, and safety laws in addition to competing market forces would make it impossible to the Ford Motor Company to perform a restorative reset that returns the company to Henry Ford's original automobile assembly line.

Though common in frequency, reset actions that return to a pre-existing state are inherently limited. However, resets that result in the creation of a new state have extended reach and opportunities.

Fundamental resets (type n° 3) create a new state based on pre-existing elements. From our viewpoint, this type of reset practically extends the limits of what would be an impractical restorative reset. In the previous example of the Ford Motor Company, we suggested that significant evolutions would make it impractical to perform a restorative reset to Henry Ford's early 20th-century model. However, a fundamental reset would allow the company to build upon the essence of Ford's work by reintroducing forgotten

principles from their past in the present environment. This type of reset feels intuitively applicable in support of a highly interpretable management idea, since the principle of revisiting fundamental elements in order to define the future can be adapted and applied in nearly any setting or environment.

Finally, metamorphic resets transform existing objects into an entirely new state. We recognize that the degree of metamorphosis can vary substantially: the sole example sentence about royal jewels could see a ring jewel transformed into a pendant. In this situation, the identity of jewels does not shift; they remain jewels. However, during our course of study, we noticed more apparent examples of metamorphic resets. For instance, a group of Israeli university students in a Fab Lab transformed vintage electronic components into an artistic sculpture of a Trojan horse. By introducing an artistic vision, printed circuit boards underwent a transformation from electronic equipment to become both an artistic substrate and a paint-like substance.

Each reset type presents unique opportunities, which we identify through their specific outcomes. Although the outcomes of resets presented in these example phrases appeared mostly desirable, we also recognize that resets may not always produce ideal outcomes. Overuse of alarms and notifications intended to trigger a reset can diminish their effectiveness. A restorative reset may not provide an appropriate response to a given situation. A wide range of risks exists when a reset introduces an entirely new state.

Ultimately, the individual or organization performing a reset must decide whether the reset action will help them achieve their desired outcome. Our proposed reset

framework can assist decision makers by outlining the potential outcomes of a reset based on a set of inputs and surrounding conditions.

Resetting innovation capabilities

Now that we've identified four types of resets based on the word's use in multiple example sentences, we want to explore how these reset types relate to innovation. Each reset action appears to create a different set of potential opportunities in relation to innovation capabilities.

Our first reset type—trigger resets—takes existing elements and returns them to a pre-existing state, typically occurring on a regular or recurring basis. This reset action is not innovative by itself. However, in practice, trigger resets almost always lead to some subsequent action. This additional action opens a path to developing innovation capabilities as a reaction to a given trigger. An overly simplistic example might describe an alarm set off by a drop in stock price. As a response to that alarm, the organization would decide to mechanically increase resources available for innovative projects.

Our second reset type—restorative resets—allows novel objects to be introduced as part of performing the reset; these new additions must merely work to return to an object to a prior state. This type of reset would require innovation capabilities in order to design the novel objects that will be introduced. For instance, we consider Company A who operates in a highly competitive industry while preserving gross margins that exceeded those of their competitors by 36%. Those margins eroded when Enterprise Z successfully entered their market two years ago. Company A could leverage innovation

capabilities to perform a restorative reset by developing a new product and revenue model that restored their gross margins.

Both of these reset types leverage innovation capabilities in order to maintain the status quo—what we call a “pre-existing state” using this chapter's terminology. We typically observe innovation framed as resulting in something fundamentally novel, rather than working to preserve a state of an object that previously existed. We find this result intellectually stimulating. Typically when one thinks of innovation, they refer to something novel. However, our framework suggests that innovations can emerge by returning to a prior state through a reset action. Based on this outcome, effective managers may require the ability to discern which objects should be reset looking backward (prior state) as opposed to those that should be reset looking forward (new state).

We now look at the two reset types that result in the creation of a new state. We recall that only three example phrases out of twenty referred to referred to this type of action. The lack of additional examples limits our ability to fully explore the nuances of these reset actions based solely on the Oxford English Dictionary use sentences.

Notwithstanding, the creation of a desirable new state, either by repurposing existing elements in new ways or introducing additional elements intuitively reflects the essence of innovation; we are confident in the assumption that these actions directly leverage innovation capabilities in most situations.

Our third reset type—a fundamental reset—uses previously existing objects to create a new state. In our previous discussion, we also referred to this action as returning to fundamentals or going back to basics. From an innovation capabilities perspective, this

action interests us because it opens the path for a complex, modern organization to revisit its “creative heritage” (Carvajal Pérez, Araud, Chaperon, Le Masson, & Weil, 2018) and origins as a source of innovation.

Our final reset type—a metamorphic reset—transforms objects into something substantially different through the introduction of new elements. The degree of metamorphosis can vary. For instance, the conversion of a passenger jet into a cargo jet simply transforms the type of jet, whereas transforming a passenger jet into modern art or a memorial fundamentally changes the identity of the object. As such, we consider that metamorphic resets have the most pronounced potential to stimulate and build upon innovation capabilities.

All reset actions—especially resets that return objects to a previous state—do not always require innovation capabilities in order to perform them. However, we find that each of these reset actions either introduces a path to developing innovation capabilities or directly requires innovation capabilities to be performed. As such, we determine that each of the reset actions has the potential to be deliberately used to develop innovation capabilities.

What types of resets do Fab Labs perform?

In the previous sections, we identified unique differences between corporate Fab Labs—an isolated work environment focused on innovation—and the organization. This analysis introduced the notion of resets and resulted in a proposed framework to qualify resets. We also explored how each reset either generates or builds upon the innovation capabilities Fab Labs are intended to develop within an organization. At this stage, we

want to identify the types of resets Fab Labs appear to perform. Emerging patterns then constitute the base for a potential central claim to support the Fab Lab management idea.

In order to identify the types of resets performed by corporate Fab Labs, we must explicitly identify the object being reset by the lab: the organization's innovation capabilities. Our analysis of this reset action builds upon the two dimensions of our reset framework. Specifically: do Fab Labs return an organization's innovation capabilities to a prior state or a new state? Is this reset action performed using existing elements or does the lab require the introduction of new, additional elements to operate?

First, we consider the state of an organization's innovation capabilities following a reset action. In the previous chapter on management ideas, we mentioned that a couple of labs observed are named after a setting that existed previously in the organization's history, such as “The Garage” which alludes to a specific garage where the company was founded. This naming behavior appears indicative of an environment that immerses individuals into a pre-existing state from the organization's past. However, upon closer inspection, we observed that this practice reflected little more than repurposing a prior state as a brand for a fundamentally new state. Beyond these naming practices, our observations did not provide additional indications that Fab Labs returned an organization's innovation capabilities to a measurable, prior state. As such, we suggest that Fab Labs rarely perform trigger or restorative resets.

Second, we consider what elements are required to introduce a new state for innovation capabilities within an organization. Individual perspectives gathered during our research interviews presented divergent views. Most individuals believed that their lab

introduced new elements to their organization, suggesting a Fab Lab performs a metamorphic reset. However, a sizable minority of individuals in these firms suggested the machines, employees, processes, and even mindset already existed within their firm, albeit in a diffused, disparate form. This latter view is more aligned with a fundamental reset, which repurposes existing elements to create a new state.

In order to reconcile these contradictory perspectives, we continued observations outside the lab to identify whether the lab introduced new elements. We found that in industrial firms and firms that create consumer products, the various elements in a lab that support developing innovation capabilities were already largely present elsewhere within the firm. In these contexts, Fab Labs perform a fundamental reset by gathering the basic building blocks of innovation capabilities—resources, processes, and mindset—in a concentrated environment.

We found an exception to the result identified above in service-oriented firms, namely consulting firms, banks, and insurance companies. In these contexts, the creation of a lab did introduce new elements to the firm. In these limited situations, Fab Labs clearly perform a metamorphic reset that invites employees of these firms to innovate around the material and tangible elements of an intangible service offering. This result appeared interesting when lab creators identified the lab's ability to cultivate a more holistic vision of their service offering for their firm.

Now that we've identified the primary reset corporate Fab Labs perform on an organization's innovation capabilities, we can refine the management idea's central claim. In most firms, Fab Labs enhance innovation capabilities by resetting disparate elements already found in the firm in a concentrated environment. In chemistry, the

probability for precipitate increases as a solution's concentration increases. By analogy, one might reasonably expect that an environment with increasingly concentrated elements would lead to increased precipitate, or innovations. In the following chapter, which builds on Article 2, we look to assess the real-world, empirical outcomes of the fundamental reset performed by four different corporate Fab Labs.

Chapter 8: Assessing the impact of Fab Labs as an innovation reset mechanism

From the earliest stages of our research, most practitioners we interviewed indicated they needed a meaningful way to qualify the performance of their Fab Lab. From our perspective, the high frequency at which this functional requirement emerged suggests that most organizations fully expect a lab to fulfill the promises made by a management idea's central claims, including its' supporting rhetoric, and technology. As such, we want to complement our central claim introduced in the previous chapter with a means of evaluating its effectiveness. In this chapter, we accomplish this by extending and enhancing a simple measurement framework to identify the impact of innovation capability resets.

Our efforts to evaluate a Fab Lab's output emerged in Article 2, where we studied a corpus of individual objects produced in four different corporate Fab Labs using over 500 photos taken in these labs. In order to develop these evaluation criteria, we found we needed to shift away from our previous focus on innovation capabilities. Although these capabilities constitute the core building blocks for innovation, their presence alone does not guarantee innovative outcomes (O'Connor et al., 2008). Instead, we seek to identify a determinant that indicates the impact of an innovation capability reset. To do this, we turn our focus towards the actual artifacts that emerge from these reset environments. In other words, the objects that were actually made in a lab.

In our article, we introduced and employed the notion of “boundary objects” (Carlile, 2002; 2004; Star, 1989) as a theoretical basis in order to identify whether the organization was able to successfully adopt the lab's output and transform them into an

innovation. In this context, the notion innovation reflects a marketable product or service.

Before we continue, we outline a key assumption that underlies our analysis. In the previous chapter, we identified that corporate Fab Labs were most likely to perform resets that resulted in the creation of a new state, rather than reverting back to some prior state. Our key assumption holds that that a new state results in different outcomes—along with the corollary assumption that differences that can be observed and compared. Thus, in order to detect the presence of a reset, we look for differences in the outputs that stem from a Fab Lab compared to outputs coming from other parts of the organization. This criteria indicates whether or not a reset has taken place. The fundamental nature of this approach could also be used to highlight resets in other situations, such as organizational restructuring initiatives, in order to measure whether the desired outcomes were achieved.

Resets resulting in the creation of new types of objects

In the previous chapter, we identified that most corporate Fab Labs perform what we characterized as a “fundamental reset” (type n° 3) to support innovation capabilities. The resulting new state aggregates extant but disparate resources, processes, and mindset into a single location: the lab. As a baseline measurement of this reset, we want to determine whether the new state introduced by the lab results in new types of outcomes.

The artefacts analyzed in Article 2 suggest that most objects produced in corporate Fab Labs differ substantially from those elsewhere in the organization in at least one of two ways.

Most often, we found differences in the organizational roles held by the object creators. For instance, a corporate sales manager without any prior engineering training or experience came to a lab to learn how to build a custom circuit board. Based on her training and role, this individual would not normally be expected to produce these types of objects as part of her work. However, in addition to her personal interest in learning, this employee also believed this technical knowledge would be beneficial in her sales role. In this type of situation, the lab performed what we qualified as a “fundamental reset” in the previous chapter: creating a new state from existing elements in the organization, including this employee who remained in her existing role.

Second, in a handful of situations we identified that the object produced appeared unique to the organization as a whole. This was apparent at a large electronics company where a team developed a unique 360° image viewing experience by cobbling together several of the company's existing products in an original way. While the components used to create this original object were all made by the company, they came from multiple divisions that would have limited interactions based on the organizational structure. As a result, the natural combination of these objects would appear improbable within this firm. Like the previous situation, the lab performed what we qualified as a “fundamental reset” in the previous chapter: creating a new state from existing elements in the organization.

When analyzing our data and examining the dynamics of these two representative examples, we wanted to verify that the lab and its' environment were a determinant element in the emergence of these new outcomes. In other terms, we first want to verify that a reset action took place. Next, we want to ensure the lab was an instrumental element in enabling the creation of that outcome.

To accomplish this, we controlled our data in two stages. First, we relied on qualitative statements made by individuals interviewed (i.e. "I could have never made this before having access to this lab."). In the second stage, we controlled these qualitative statements by comparing the resources available in that individual's workspace and the resources used to create the object (i.e. specialized design software, laser cutter, etc.). In most situations, their personal workspaces did not have reasonable access to the resources used to create the new object. As a result, we consider that the lab had a direct impact (i.e. it performed a reset) on the ability to generate these new objects.

Qualifying how new objects impact innovation capabilities

Now that we've determined in the previous section that the lab successfully enables new outcomes, we want to identify whether these objects demonstrably impact an organization's ability to innovate. By this, we mean measuring impact through tangible and observable means.

Most objects we identified that were created in labs represent something novel, especially relative to the object's creator. Throughout our research, we observed countless situations where novelty was perceived as synonymous to innovation. This creates a challenge in environments where the term "innovation" is held to a more

exacting standard. Most managers of the firms we studied ultimately expect an innovation to support growth or work to achieve some of the firm's goals. While novelty reflects one aspect of innovation, it remains insufficient to demonstrate an impact on innovation capabilities. Instead, we refer back to the two outcomes expressly identified in our managerial representation of corporate Fab Labs in chapter 6: the ability to create new products or markets and the ability to facilitate organizational change.

In Article 2, we identified that the vast majority of objects studied effectively never physically leave the lab environment, or they leave the lab as a personal creation with no further organizational involvement. We consider these objects to be “novelties.” From an organizational perspective, the novel objects created in a lab have yet to be catalyzed into an innovation.

Ultimately achieving this far more stringent criteria for innovation within the context of a large organization can rarely be accomplished by a single person, or even a small team. As such, novel objects on a path towards innovation must inevitably leave the Fab Lab environment and evolve as they interact with multiple teams and departments. In Article 2, we identified a handful of novel objects that began to reach out and interact with other areas of the organization. Over time, these initiatives became legitimate products, folded into established business units, and managed like other products.

These novel objects act as seeds for innovation; the realization of their full potential requires resources that greatly surpass what the few hundred square meters the Fab Lab environment provides. Using the three types of boundaries from Carlile's (2002) boundary objects framework, we are able to assess the level of interactions an object can

maintain across various organizational boundaries. These three boundary levels—syntax, semantic, and pragmatic—respectively indicate whether:

1. a common, shared language exists regarding an object and its fundamental purpose (syntax)
2. the object has significance or meaning to each party (semantic)
3. diverse parties can successfully collaborate around and contribute to the evolution of the object (pragmatic)

We found that all objects that originated in the Fab Lab that were considered “innovations” by the organization required an object engage in the most mature levels of interaction, described in Carlile's framework as pragmatic boundaries. In other words, the novel objects created in the company's lab successfully created meaning for the rest of the organization and interact with various teams. Despite the strong rhetorical claims surrounding the Fab Lab management idea as an essential vector for developing innovation capabilities, we were surprised by the dearth of labs where these sophisticated objects emerged. In our analysis of objects in Article 2, we found that a single lab was structured to repeatedly generate objects that could ultimately cross organizational boundaries to become an innovation.

Although the type of reset performed by these labs is identical, this result invites additional research in order to identify key elements that can lead to outcomes that support innovation capabilities.

The Fab Lab itself resetting the organization

Our focus on objects created in Fab Labs presented in Article 2 determined that the direct impact of these outputs on most firm's innovation capabilities remains limited. However, we have no evidence that suggests the impact of a Fab Lab is exclusively limited to the objects produced in that space. This leads us to briefly consider a complementary perspective: could the Fab Lab itself be considered a boundary object? How might we assess the impact the Fab Lab itself has on resetting an organization's innovation capabilities?

We've previously determined that the reset performed by Fab Labs results in the creation of a new state within the organization. We assume the introduction of this new state will induce observable shifts and transformations as an organizational structure emerges to support this new state (Giddens, 1984).

Using the same boundary object framework, we believed we could observe adaptations in innovation capabilities induced by the existence of the Fab Labs. From this perspective, lab creators and managers were the creators and representatives of the Fab Lab boundary object. To identify whether the lab crossed syntax, semantic, and pragmatic boundaries, we could observe the interactions these individuals had with other departments in the organization. We could observe outcomes by identifying joint actions and resulting change that occurred in both the lab and the other department.

A single case from an industrial firm we studied is used to illustrate the three boundaries and resulting changes. In this firm, the team of lab founders identified a hurdle individuals creating original objects would eventually face: collaborating with the

company's legal and intellectual property departments. They wanted to establish a simplified model that would enable small project teams to avoid significant risks without “crippling their ability to focus on developing their product or service.” One of the lab creators approached an existing contact in the legal department and began working to cross the three organizational boundaries:

In order to cross the syntax boundary, the lab creator outlined the existing legal review process that applied to new products. He explained the Lab was intended to create new, original products using small ad hoc teams. These teams didn't have the same resources as the company's formal projects, which complicated the ability for these teams to interact with the legal division. From the legal manager's perspective, he understood the company's strategic need to create new products and his department's role. He could talk about the Fab Lab from a somewhat familiar frame of reference.

As the discussion continued between these two individuals, the semantic boundary was crossed almost implicitly. The lab creator understood the legal team's role in assisting nascent projects avoid major legal pitfalls, and the legal manager began to understand the lab's goal of generating a steady flow of nascent projects. Each party understood the other's respective work, and it became apparent that maintaining existing process would be unrealistic: the project teams in the lab weren't structured enough to support the legal team's process, and the legal team wasn't adequately staffed to handle an increased workload of multiple nascent projects.

With the mutual understanding of these parameters, the lab creator then crossed a pragmatic boundary by proposing an abridged legal framework adapted to the lab. As the conversation continued, the legal manager suggested modifications to the services

provided by the Fab Lab manager's team to acquaint and prepare project teams to encounter key legal questions. The end result of this initial conversation and subsequent exploration performed by the legal team was the introduction of a lightweight, accelerated legal review process. Although the new state introduced by the Fab Lab acted as the principal motivation for this change, this new legal process benefited more formal, early stage projects within the company that didn't emerge inside the lab environment. As such, we consider that the lab as an object contributed to the firm's broader innovation capabilities.

In all the labs we studied, we could identify organizational shifts that crossed pragmatic boundaries when considering Fab Labs as boundary objects. This suggests the existence of a lab has some impact on a firm's innovation capabilities. From our analysis, a correlation appeared between the sophistication of boundary objects created in the lab and the number of organizational transformations that took place as a result of the lab. The scope of our empirical data limits establishing a causal relationship between these two data points. However, one manager remarked that the existence of new, innovative objects that needed to make it to the market created a sense of urgency that helped push through some of the transformations that took place in his department. From this viewpoint, we suggest that multiple sophisticated boundary objects can act as an impetus for organizational transformations that significantly contribute to increased innovation capabilities.

Longer-term implications for Fab Labs

In this chapter, we introduced a mechanism for assessing the impact Fab Labs have on a firm's innovation capabilities based on measurable outcomes. We did this in order to determine whether Fab Labs fulfill the proposed central claim of increasing a firm's innovation capabilities by resetting those capabilities in new ways.

We started by recalling our research presented in Article 2 that examines the objects produced in four different Fab Labs. We found that outputs vary greatly between each lab studied. Based on output objects alone, only one lab during our field research appeared to produce objects that crossed the most sophisticated organizational boundaries. We then developed an alternative perspective of considering the lab as an object itself. We determined that in all situations studied, the lab crossed organizational boundaries that enabled transformations required to support innovative activities. In other words, the Fab Lab itself—not its resulting outputs—performed the primary innovation reset in most firms.

From our perspective, this result ultimately calls the long-term sustainability of Fab Labs into question. Once an organization adapts all areas of the firm to support the types of innovative project teams labs were intended to support, an organization would theoretically obtain no additional advantage by maintaining the lab.

In these situations, lab managers may want to identify how they can reset activities within the lab to encourage the creation of more sophisticated objects. We believe the creation of this new state would require the introduction of organizational elements that were initially excluded from many lab environments, such as more formal project

governance. However, we are quick to note that the reintroduction of formal governance wouldn't be identical to the pre-lab state. Rather, it would reflect the adapted form of governance that emerged as a result of viewing the lab as an innovation-enabling boundary object. In this sense, the innovation activities intended to take place in a lab would only be made possible by adopting organizational elements that came after introducing a lab. Ultimately, this dynamic takes a considerable amount of time to bear fruit.

As such, we suggest that organizations who choose to implement the Fab Lab management idea should adopt a long-term perspective to developing their innovation capabilities. We caution that short-term views and repeated major shifts in corporate strategy are not ideal environments for labs to effectively perform resets. In order to measure progress along their journey, managers can assess the types of boundaries crossed by both the lab's team and the teams creating objects. We also encourage lab managers to remain proactive and incorporate new elements from the organization as they're developed to support innovation activities.

Chapter 9: Observing resets in action: opening an alternate path to creativity & innovation

In the previous chapter, our analysis focused on outcomes enabled through the reset performed by Fab Labs. This *ex-post* approach does not consider what impact a reset environment has on objects as they are being created. In this chapter, we consider whether the new state present in a corporate Fab Lab environment alters the process of object creation. For this approach, we look at the creation processes observed *in vivo* during our action-based research.

To begin our comparison, we recall the predominant design and creation practices found in the organizations we studied. We found that—like most organizations in the late 20th century (Garel, 2013)—these firms had all adopted formal project management structures as the foundation of their design activities. At the outset of each project, the definition of project scope and objectives enable managers to identify and allocate the resources required to pursue the endeavor. These formative project stages result in establishing a cohesive project group before creative activities commence.

Cohesion—simply defined as “the action or fact of forming a united whole” (Oxford English Dictionary, 2010)—is commonly considered a prerequisite to design processes (Dubois, 2015). As a matter of practice, most contemporary organizations invest substantial resources and effort in creating a sense of cohesion among individual attitudes and knowledge as a precursor and prerequisite to change (Beer & Nohria, 2000).

We wanted to identify whether the reset environment found in Fab Labs maintained the institutionalized pattern of cohesion preceding creation.

To perform this analysis, we looked for a simple, observable indicator of cohesion. We observed that at the outset of all formal projects in the organizations we observed, a newly formed project team inevitably begins their interactions with some form of introductions. Typically, individuals will introduce themselves by stating their name and their role while participating in a project. Through this process of personal introductions, the project team establishes collective coherency and an institutionalized form of cohesion prior to engaging in creative design activities.

Design activities occurring in Fab Labs frequently demonstrated that the opposite is also possible, even ordinary. The cohesion-oriented behavior centered on personal identity and defined roles we observed in the organizations didn't always hold true in the Fab Lab environment. In at least twenty recorded instances throughout our active observations, personal introductions (i.e. "Oh hey, by the way, what's your name?") came after an hour of actively working together on a design problem and sharing knowledge. A countless number of interactions related to design tasks we observed took place between individuals who did not know one another's name—even over extended periods of time. This was as evidenced by the fifty-seven recorded instances of individuals who asked us—occasionally with signs of personal embarrassment—what someone else's name was after collaborating with another individual over an extended period of time. We were especially amused when the individual asking us clearly didn't even know our names.

Put simply, we observed that design activities in Fab Labs can occur in the absence of cohesion. Here, the emergence and extension of the identity of the object being created becomes a central, unifying force. Associations came as a result of an individual seeing an opportunity to contribute to the evolution of the identity of that object.

Most interactions around objects appeared natural and convivial; individuals we interviewed qualified their time designing an object in the lab as a form of “play.” While the object-oriented approach appears out of place when compared to the organization, all visible indicators suggested these dynamics felt intuitive and natural to individuals who engaged in lab activities.

This approach feels out-of-place compared to most projects in the organization. Due to the prevalence of establishing cohesion prior to creation in organizations, we questioned whether individuals would inevitably attempt to apply this pattern to their interactions in a lab setting. Interestingly, this behavior only appeared in a specific context.

While consistent patterns of cohesion—or rather, the ability to create in the absence of cohesion identified—we now discuss a common exception in our observations. These exceptions occurred when the Fab Lab organized specific events, such as “hack-a-thons” and other semi-formal design challenges. The premise of these events was for a team to produce a given object in a short period of time. As each project team was constituted, we observed that they would adopt the pattern of personal introductions typically found in other project teams outside the lab. However, we observed that after team members stated their name, they would not state a presumed role for the project, such as marketing manager or software engineer. Instead, they would briefly describe their interests and skill sets they believed they could contribute to the project team. Once the introductory exercise was completed, the ephemeral project team would organize itself and attribute roles based on expressed skill sets and personal interest.

We recognize these initial observations are based on a highly self-selecting population: all competition participants were gathered together for a specific purpose, and each

expected a general approach. We believe our initial observations could be enhanced from at least three perspectives.

First, we propose experimenting with controlled attempts to introduce typical cohesion-centered behaviors in a lab environment in order to observe how these practices impact who participates and the resulting outcomes. For example, by introducing formal roles at the outset of a project, would we observe a difference in the skills contributed by a given individual? Would the identity of an object evolve as much over the course of design activities?

Second, we suspect other research disciplines could provide additional insight. For instance, we consider the frequent use of the word “play” coupled with what we observed to be indicative of some intuitive social behaviors. While the behaviors observed stood in stark contrast to most organizational practices, we do not believe they were spontaneously acquired. The dynamics observed in labs feel somewhat analogous to the dynamics of young children who create an ephemeral fictional universe, regardless of whether they know one other. This perspective would support the socially intuitive but institutionally unorthodox patterns observed in labs. We believe researchers in early childhood development—and other fields—could contribute additional clarity and definition.

Finally, we believe a critical perspective to our findings should be developed. One might argue that the ability to jump in to participate in an ongoing design activity is enabled by a form of pre-existing cohesion. In other words, cohesion already exists and enables immediate creation. For example, one lab manager we spoke with called her lab a “climate of confidence.” By climate, she referred to a form of social norms that openly

welcomes Fab Lab newcomers as potential contributors and community members. In addition, nearly all individuals found on-site already “belong” to the broader corporate community and are assumed to share a common goal in support of the organization. From this perspective, cohesion precedes all creation by way of the community's foundational rules and operating principles.

While additional research is needed to continue exploring these findings, we believe they represent an opportunity for innovation managers to use design activities as an introductory tool as they work to “diffuse” new attitudes (Börjesson & Elmquist, 2011) or “orchestrate” (O'Connor et al., 2008) a company-wide appetite for innovation.

Chapter 10: Conclusions & management implications

This thesis investigated corporate Fab Labs. At the outset of our research, these spaces were only recently emerging within organizations and nascent research objects. Our research, presented in this document along with three supporting papers, intended to 1) increase our understanding of how these spaces impact an organization's innovation capabilities, 2) contribute to the “theorization” (Birkinshaw et al., 2008) of Fab Labs as a management idea, and 3) indicate managerial implications of these spaces. The following sections describe our outcomes across these three dimensions.

Conclusion

This thesis first examined corporate Fab Labs through the prism of a simple innovation capabilities framework. This vision was selected based on the stated expectations of Fab Lab founders and other managers in their organization. Our descriptive analysis, developed in Article 1, identified the basic ingredients provided within these spaces to promote innovation capabilities.

Our preliminary analysis identified that Fab Labs provide few novel resources to the organization. This led us to consider what representation management teams in these organizations held regarding Fab Labs, which we developed in Chapter 6.

Adopting a grounded approach to respond to this question, we identified statements in our empirical data from managers and other key actors about the intended outcomes and objectives of a Fab Lab. While the specific strategies described to achieve the desired outcomes varied, we identified a common objective or vision across all our

interviews: develop a firm's ability to innovate. This analysis, paired with observed behavioral patterns where firms stood up their “Fab Lab” as a specific solution to a specific type of problem, led us to hypothesize that Fab Labs could be a management idea.

Management ideas represent a generally accepted strategy one can adopt to resolve a frequently-encountered challenge. A key characteristic of management ideas is the ability to adapt and interpret them across multiple contexts and circumstances (Rauth, 2015). This is referred to as interpretability, which facilitates the adaptation of a management idea to any set of circumstances found within various organizations. Our research examined the interpretability of rhetorical and technical elements that compose the Fab Lab management idea. The absence of interpretability in either of those two dimensions would indicate that Fab Labs are not appropriately represented as a management idea.

We found that Fab Labs appear highly interpretable in corporate settings in both rhetorical and technical terms, suggesting that we could appropriately consider them a management idea. The central claim or purpose for creating a lab was to increase the firm's ability to innovate. However, the reactions we observed once a Fab Lab was adopted in an organization hinted to a significant shortcoming in the “theorization” (Birkinshaw et al., 2008) or “packaging” (Rauth, 2015) of the management idea. This central claim carried by Fab Labs is open to a full range of expectations: some expect a modest place for employees to embrace curiosity and try new stuff out, while others expect the ability for labs to generate new, pioneering, billion-dollar businesses in a short timeframe.

The lack of clarity around a Fab Lab's value proposition within an organization and its associated expectations may contribute to the increasingly apparent dynamic of labs as a passing management fad. Following a rush to establish labs in the time period from 2014–2016, new initiatives became an odd rarity. This position served as the foundation for our contributions to the theorization of Fab Labs, starting with our analysis performed in Chapter 7.

Theoretical contributions & future research

Building upon our qualification of Fab Labs as a management idea, we made two complementary theoretical contributions in Chapters 7 & 8, while opening the door to further research in Chapter 9.

Our first contribution builds upon the identification of some of the unique properties of a corporate Fab Lab and ultimately leads to a framework to create opportunities to innovate. In most large organizations, labs house an alternate operating environment that modifies standard policies and processes. This environment results in eliminating common divisions of labor, blurring notions of expertise, erasing bureaucracy, and explicitly enabling individual expression. This lab environment temporarily alters the effects of the broader organization.

Based on these differences, we elaborated a framework to characterize the action of creating conditions or environments that can enable innovations to emerge in Chapter 7. We called this action a “reset” and explored the multiple properties and meanings of this word. This action describes the ability to revert to a previous state or create a new state, either through the use of existing elements or introducing new elements. Each type of

reset enables different types of outcomes, which uses new or existing elements in order to create a pre-existing or new condition. Each of these actions can be used to innovate.

While our reset framework identifies the types of outcomes each of the four reset actions can produce, it cannot directly inform a manager whether that particular action is desirable or will provide an appropriate response for a given situation or condition. As such, this framework can inform decision-makers of potential paths to a strategic outcome, but ultimately, they will have to assess whether the selected reset action will result in appropriate outcomes for the situation.

As we studied various Fab Labs, we observed they deliberately enable innovation capabilities by creating a simpler organizational environment that existed previously at some point in the organization's existence. In other words—and somewhat paradoxically—labs provide a mechanism to innovate by looking backwards to a time in the organization's history where the structure was smaller, flatter, and inherently less preoccupied by bureaucratic concerns. While this appears to be an intuitively familiar setting for innovation to emerge, it limits labs to performing only one of four reset actions. Continued exploration could adapt Fab Labs to the other three reset actions in order to identify resulting outcomes.

Our second contribution—developed in Chapter 8—is complementary to our primary theoretical contribution: a tool to assess the impact or effectiveness of a reset action. Since innovation resets result in a fundamentally different environment, we consider that by definition resets should result in alternative outcomes. In order to control whether Fab Labs actually performed a reset on an organization, we started by examining the tangible outputs of labs: the objects produced. To accomplish this, we

adapted an established theory in Article 2—boundary objects (Carlile, 2002; Star, 1989)—in order to gauge the types of interactions taking place surrounding objects made in labs. These interactions are critical stepping stones in support of innovation activities. If objects are crossing organizational boundaries, they are making continued progress towards becoming an innovative product, service, or offering.

On the contrary, objects that do not cross organizational boundaries sit on shelves or eventually find their way to the dustbin. Although these objects may help develop an individual employee's skills, they do not measurably impact the innovation capabilities of the broader organization. We found that some lab configurations appear to consistently deliver objects that reach the most sophisticated level of interactions, while others do not. Most objects we studied fell into this category, which may call into question the utility and sustainability of a lab. Labs that don't present these characteristics or outcomes may need to recalibrate their practices with management support.

In parallel to our assessment of the boundaries crossed by individual objects, we also identified the lab itself as a boundary object. In a handful of companies, we observed other departments in the organization adapted the services they provide to account for the different environment offered by the lab and its resulting outcomes. We identified a strong correlation between the sophistication of objects coming out of a lab and the extent of mutual adjustment performed by the organization in order to accommodate these novel objects. Our dataset remains insufficient to establish a causal relationship between the boundaries crossed by the lab as an organizational entity and the maturity of the labs resulting objects, but we believe it constitutes a compelling working hypothesis for continued research to build upon.

In addition to these research avenues, we also pointed to a different social dynamic for innovation activities found in corporate Fab Labs and described in Chapter 9. Instead of following typical organizational patterns where structural cohesion is established prior to pursuing creative activities, labs suggest that the opposite approach is possible. While the ability for labs to do this remains non-exclusive (Dubois, 2015), this dynamic could be leveraged more broadly. Such practices would come with significant organizational ramifications, opening the door to expanded flexibility in roles and responsibilities. Continued research could identify the desirability and limits of this dynamic while informing several practical, managerial applications.

Managerial implications

The ramifications of Fab Labs as a management idea and their potential impact on an organization carries several implications for management teams. We believe these implications are applicable to both traditional rank-and-file managers as well as individuals who are trying to manage and enact change within their organizations regardless of hierarchical responsibilities.

First, by qualifying Fab Labs as a management idea, we implicitly recognize that they are a technical solution intended to resolve a particular challenge or issue. In practice, corporate Fab Labs are intended to enable an organization to do things differently. However, this objective carries several provisos: for a lab to be successful, it appears that an organization and its managers must be willing and able to adapt and change other parts of the organization. From this perspective, the lab itself is an agent for change; as other areas of the organization adapt to support its activities, innovation can begin to flourish.

While most leaders are willing to pursue exploratory activities in fundamentally different ways, many are under constant pressure to deliver operational results. This tension may decrease the appetite to embrace and adapt broader areas of the organization to support new ways of doing things. Under such circumstances, implementing a lab may not be the best fit.

Second, we highlighted the ability to perform a “reset” to an organization's innovation mechanisms. This action results in a different state or condition that is expected to enable innovation. The elements used to perform this reset can be adjusted based on the types of outcomes desired. We suggest that managers assess the potential outcomes and risks associated with each type of reset in order to successfully lead change.

Finally, we identified a means of assessing the impact of a lab based on the tangible objects produced in that environment. In order to successfully lead to innovation, novel objects must be understood by the larger organization. In the event that most objects fail to cross the most basic boundaries, lab managers may want to adapt or adjust the way they enable interactions. From our observations, we identified that this strategy is most commonly developed “along the way” (Avenier, 2011). This is to be expected, as a reset introduces a certain degree of uncertainty and unknown that each organization must address in a way that aligns with existing capabilities.

While the Fab Lab environment can reasonably be expected to produce *different* results than what the organization presently generates, it still offers no guarantee of reaching innovative outcomes. Labs can be a meaningful and valuable resource along this journey. Successfully orienting those efforts to reach the intended outcomes will still require careful piloting and direction, or in other words: management.

Glossary

- CAD - Computer-Aided Design
- CBA - Center for Bits & Atoms at the Massachusetts Institute of Technology (MIT)
- CNC - Computer Numerical Control
- DO2 - Design Oriented Organizations (*Hatchuel et al., 2006*)
- MIT - Massachusetts Institute of Technology
- NSF - United States National Science Foundation

Summary of tables & figures

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APPENDIX

— Article n° 1 —

*“Resetting innovation capabilities:
the emergence of corporate Fab Labs.”*

Matt Fuller & Albert David, 2016

— Article n° 2 —

*“Making nothing or something:
corporate Fab Labs seen through their objects
as they cross organizational boundaries.”*

Matt Fuller & Albert David, 2017

— Article n° 3 —

*“Fitting squares into round holes:
Enabling innovation, creativity, and entrepreneurship
through corporate Fab Labs.”*

Matt Fuller, 2017

— Résumé de thèse en français —

— Article n° 1 —

*“Resetting innovation capabilities:
the emergence of corporate Fab Labs.”*

Matt Fuller & Albert David, 2016

Resetting innovation capabilities: the emergence of Corporate Fab Labs

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Summary

Innovation capabilities, a combination of organizational resources, processes, and mindset, describe a form of readiness or "internal driving energy" to innovate. At times however, to continue innovating, a firm may need to fundamentally reconfigure these components—a processes we call a "reset". In this paper, we explore the reset concept through existing literature and by presenting the case of Corporate Fab Labs, emerging structures that are expected by firms contribute to the organization's innovation capabilities. Our study of 18 Labs across ten industries is used to identify types of innovation capability resets, such as a reset of an individual resource, process, or mindset, in addition to suggesting more complex reset configurations. This research can be particularly useful to managers faced with substantial barriers to innovation, as it proposes a model for enabling innovation that can function, at least initially, with what's "on hand".

Key words

Innovation capabilities, reset, Fab Labs, institutional entrepreneurship, management

Introduction

Despite continuous advances in innovation management, some individuals could fear that their companies lack the ability to successfully face increased competition and pressure to innovate. Such concerns are not entirely unfounded, as several large companies have failed to anticipate or successfully respond to new types of competition (Christensen, 1997).

Innovation capabilities describe a form of organizational readiness to both create and respond to new opportunities (Börjesson & Elmquist, 2011). They're an "internal driving energy to generate and explore radical, new ideas and concepts, to experiment with solutions... and to develop them into marketable and effective innovations" (Assink, 2006). Capabilities are not static resources; management practices and tools are required to continually develop, orient, and maintain them (Hatchuel, Le Masson, & Weil, 2006).

Over time, tools for building innovation capabilities have become more efficient through closer integration with a firm's primary activities and reducing overall costs tied to innovative projects. At one point, several empirical studies pointed towards establishing isolated, self-organizing project teams (Takeuchi & Nonaka, 1986) and autonomous task forces (Wheelwright & Clark, 1992) in order for innovative projects to have a chance to succeed. While these teams could add to innovation capabilities, they did so at arms-length from the corporate structure. Because of this separation, the organizations did not benefit from the transformative adaptations needed to create a stable environment for repeated, disruptive product development (Damanpour & Evan, 1984).

Structures for institutional entrepreneurship (Boxenbaum & Battilana, 2004; DiMaggio, 1988) tried to reduce organizational separation by enabling highly motivated employees — *intrapreneurs* — to innovate in the workplace, regardless of an employee's position or responsibilities (Pinchot, 1985). More recently, configurations such as open innovation (Chesbrough, 2006), reverse innovation (Govindarajan & Ramamurti, 2011), and frugal innovation (Radjou, Prabhu, & Ahuja, 2012) try to approach this problem by using 'less to do more'. Despite these advances and the strategic importance of building innovation capabilities, such solutions are often applied in an incomplete, haphazard, or 'bolted-on' fashion, frequently due to their perceived cost and complexity (Hamel & Tennant, 2015).

In this paper, we present an alternate means of building innovation capabilities that—at least initially—works very differently, but with what's on hand. We call this approach a "reset". We explore this notion by reviewing existing literature on innovation capabilities, their related frameworks, and ways that they can be reset. We then present an emerging mechanism for building innovation capabilities: Fab Labs. We then outline their adaptation to corporate settings as a means of

contributing to a firm's innovation capabilities. Following this description, we outline our study conducted in 18 Corporate Fab Labs across ten different industries. We present our results in terms of how Corporate Fab Labs are presently used to reset innovation capabilities. In conclusion, we present a series of managerial implications in terms of resetting innovation capabilities.

Theory & Descriptions

In this section, we start by reviewing different views of innovation capabilities, existing frameworks for assessing innovation capabilities, and cases of innovation capability resets implicitly present in scientific literature. We present the origins of Fab Labs, initially a community outreach program tied to a Massachusetts Institute of Technology (MIT) research program launched in 2001. We briefly explore these initiatives from an innovation capabilities standpoint. Finally, we describe the subsequent adoption of the Fab Lab model within corporate settings as a means of enhancing innovation capabilities.

Innovation capabilities

The need to innovate is of strategic importance to most firms. Although the concept of innovation is multi-faceted, we employ a broad definition that refers to the introduction and diffusion of something that's new or improved, such as a product, a service, or even a management practice. The capability to innovate is broadly understood as the ability to successfully identify and exploit new ideas (Lawson & Samson, 2011), or in other words, "doing different things in different ways" (Francis & Bessant, 2005). A number of firms hope to build innovation capabilities on an organization-wide basis, such as those trying to create a setting for "innovation from everyone, everywhere" (Hamel, 2006).

Innovative activities within firms are often portrayed in scientific literature as isolated processes or outcomes (Crossan & Apaydin, 2010). Much attention is paid by practitioners and researchers alike to specific mechanisms that can enhance capabilities within firms, such as internal social networks, brainstorming and design sessions, and alternative office configurations. They are typically implemented with the expectation that innovative projects and strategies will emerge through the use of these tools. However, the relative success or failure of such tools resides in their ability to interweave the fibers of innovation throughout an entire organization, rather than being applied as a type of patch to cover-up strategic or sensitive areas (Hamel & Tennant, 2015).

For some, the capability to innovate is considered to be a dynamic capability, rather than a process or its result (Lawson & Samson, 2011; O'Connor, 2008; Teece, Shuen, & Pisano, 1997). As such, research positions on building innovation capabilities may describe various management tools, instruments and mechanisms used to innovate

as a means of developing innovative managerial practices or organizational structures. Examples include studies of “design-oriented organizations,” which focus on new knowledge generation, or the re-use of existing knowledge through novel concepts, as a core entry point to organizing innovation within firms (Le Masson, Weil, & Hatchuel, 2010). Detailed research of “breakthrough innovation” takes a broader, systemic-view and proposes seven interdependent elements that, when implemented in concert, contribute to innovation capabilities, such as organizational structure, exploratory processes to generate new knowledge, and appropriate metrics for evaluating innovation capabilities (O'Connor, 2008). Börjesson & Elmquist (2011) suggest that innovation capability is best understood as the “muscles for innovation”—a form of readiness rather than an indication of past performance.

To avoid a patchwork approach to innovation, these muscles must be developed throughout the entire organizational body using different types of exercises adapted to each muscle group. While these theoretical foundations are careful to stress the importance of orienting the entire firm towards innovation, they primarily describe developing innovation capabilities in specific settings for incubating or accelerating the creation of new products or services. As such, these environments and their accompanying augmented innovation capabilities are difficult to transpose in other areas of large organizations, such as purchasing, logistics, finance, legal, and human resources (Dougherty & Hardy, 1996). Such adaptations require significant reconfiguration, which could result in losing or spoiling delicate, emerging innovation capabilities. In the following sections, we outline an alternate approach which avoids importing or transferring innovation capabilities by performing a “reset” which can allow such capabilities to naturally take root.

Innovation capability frameworks

Frameworks describing innovation capabilities clearly describe several elements for building innovation in all areas of the firm, such as promoting an innovation-friendly culture, or drawing upon external knowledge sources (Björkdahl & Börjesson, 2012; Lawson & Samson, 2011; O'Connor, 2008). While each of these frameworks contain six to eight interconnected dimensions of innovation capabilities, they are each structured around three core components described in Table 1: resources, processes, and mindset (Börjesson & Elmquist, 2012; Christensen, 1997).

Table 1: Basic elements of innovation capability frameworks

Core capability component	Börjesson & Elmquist (2012)	Christensen (1997)
Resources	Knowledge and competence base, technology, networks and relations.	People, equipment, technology, product design, brand, information, cash, & relations with external partners
Processes	Organizational structures, managerial systems, generative processes, ways of working	Activities used to transform inputs into higher value outputs and include the patterns of interaction, coordination, communication, & decision making in the organization
Mindset	Values/norms/culture, how decisions are taken	Criteria used for decision-making, or the mindsets of the decision makers

These three building blocks are interdependent. For instance, approaches that aim to develop new processes may induce the creation of specific resources or foster new mindsets. Throughout this paper, we retain these three core components—resources, processes, and mindset—as a means of discussing and analyzing mechanisms that increase and reset innovation capabilities.

Resetting innovation capabilities

Literature on organizational change evokes the role of defensive routines (Argyris, 1985) in structural inertia (Hannan & Freeman, 1984). Summarizing Hannan and Freeman’s structural inertia model, Amburgey, Kelly and Barnett (1993) assert that “reliability and accountability are high when organizational goals are institutionalized and patterns of organizational activity are routinized.” Thus, the very characteristics that give an organization stability also generate resistance to change and reduce the probability of change. As such, “resetting the clock” (Amburgey *et al.*, 1993) might be hazardous, allowing core competencies to become core rigidities (Leonard-Barton, 1992).

Generally speaking, a reset involves restoring something to a pre-existing state or condition, or setting something up again, potentially in a way that differs from a prior configuration. Fundamentally, any change process or project includes redesign, hence a part of reset. For instance, Lewin’s (Lewin, 1947) classical “unfreeze-change-refreeze” model of change includes some reset in the unfreeze phase, for instance lightening control on production workers in order to restore participative capabilities (Marrow, Bowers, & Seashore, 1967). This works like an “undo” function, moving the organization back to a less formalized, more open state.

Resets can vary in multiple dimensions and in relation to the surrounding context. For instance, a reset can vary in intensity and frequency, such as a simply restarting a computer rather than purchasing a new laptop or reinstalling the operating system

every time it malfunctions. Resets can also be preventative or reactionary in nature, such as replacing a vehicle's tires showing wear rather than waiting for a potentially dangerous blow-out on the highway. Finally, resets can vary in terms of embeddedness and complexity, at times resulting in the use of parallel configurations—using existing resources, processes, and mindset in their prior configuration while building a new configuration.

Although most innovation capability literature focuses on building or maintaining new capabilities, the notion of resetting innovation capabilities is implicitly present through descriptions of implementing new configurations. But no publication explicitly focuses on the process of resetting itself. In this paper, we logically explore approaches to resetting innovation capabilities in relation to the three interdependent components: resources, processes, and mindset.

Resource-oriented resets

Resource-oriented resets of innovation capabilities include a near-total lack of resources like in *jugaad* innovation (Radjou et al., 2012) or, on the contrary, having all relevant resources at hand: when creating his new, larger research laboratory, Thomas Edison specifically placed well-stocked supply closets at the heart of the complex to ensure immediate proximity to supplies needed by his team of inventors (Millard, 1993). Resets can also include changes in the nature or origin of resources: resources from peers in communities of practice (Orr, 1990), resources from users in user-driven innovation, or resources from the crowd like in open knowledge-sourcing systems. Resource-oriented resets also include introducing new potential resources and then waiting to see what happens: a second-order logic of change. For instance, in the 1980s, the Parisian public transit operator RATP decided to acquire two thousand minicomputers and place them throughout the company with the sole intention of seeing what individuals would create using these new tools (Bouchikhi, 1988).

Process-oriented resets

Process-oriented resets of innovation capabilities include task-forces and autonomous project teams, which are generally organized in a much lighter and simpler way than the corporate organizations from which they are detached: a reset is made possible because these entities are totally disembedded from their parent structure. Native independent structures within an established sector (e.g. Local Motors, in the automotive industry or Voltair, the designers of E-fan, the fully electric plane by Airbus) can perform process-oriented resets compared to larger and older industrial corporations. Project management practices in the manufacturing industry underwent significant resets in the 1990s, implementing heavyweight project management structures in order to drastically shorten product design cycles.

Mindset-oriented resets

Mindset-oriented resets generally correspond to management ideas that embrace all sides and levels of the target organizations. Design thinking (Rauth, 2015), lead-user innovation (Hippel, 1986), Blue Ocean strategy (W. C. Kim & Mauborgne, 2005) are examples of such resets: their implementation might suppose resource- and process-oriented resets, but they first represent new paradigms in innovation management theory. If a reset is used as a type of “undo” function, mindset-oriented resets also include processes to remove existing points of fixation. “Unfixing” is a cognitive phenomenon that requires identifying a key dimension of the dominant design, which allows innovators to overcome blind spots in established mindsets (Agogu   et al., 2014). For instance, considering a mobile phone as a potential remote-control device and not only as a telephone was a key “unfix” moment in the early 2000s for Telia, a Scandinavian telecom company (Le Masson et al., 2010:265).

Fab Labs

Launched in 2001, Fab Labs are an educational outreach program stemming from MIT’s then newly founded Center for Bits and Atoms (CBA). The CBA research program explores digital fabrication, or the ‘programming’ of physical matter capable of “making (almost) anything” (Gershenfeld, 2005). This process requires inventing new, highly specialized digital fabrication machines. Building these new, innovative machines requires significant resources, including a multi-million dollar investment in a full range of high-end manufacturing tools, such as milling machines, supersonic water jets, industrial laser cutters, 3D printers, atomic microscopes, etc.

Fab Labs originated as a structure that provides a small subset of resources found in the CBA research laboratory, especially in impoverished communities and developing nations. As such, a number of ‘prosumer grade’ manufacturing tools are typically found in Fab Labs, in addition to a range of community-produced, open-source documentation for using these tools (Gershenfeld, 2012).

The name “Fab Lab” has a double meaning. Initially a simple contraction of ‘fabrication laboratory’, CBA conceived Fab Labs as an immersive and pedagogical extension of their research program and fabrication facilities. After anecdotal observation of social, economical, and creative outcomes, members of the CBA research team billed the initial Labs ‘fabulous laboratories’ (Gershenfeld, 2005; Mikhak et al., 2002). Examples of observed outcomes from initial Labs and subsequent initiatives independent of MIT are summarized in Table 2.

Table 2: Fab Lab externalities

Type of externalities observed in Fab Labs	Examples from Fab Lab literature
Social	<ul style="list-style-type: none"> • Learning opportunities in low-income neighborhoods and impoverished nations • Intergenerational activities • Peer-to-peer knowledge transfer • Construction of an active, international community
Economic	<ul style="list-style-type: none"> • New business and job creation • Local material sourcing • Skills training leading to job promotions
Creative	<ul style="list-style-type: none"> • Rapid prototyping and iterative creation • Unique, highly personal creations • “Frugal” solutions

Sources: (Dyvik, 2013; Gershenfeld, 2005; Mikhak et al., 2002; Taylor, Hurley, & Connolly, 2016)

The existence of Fab Labs and their byproducts are frequently used to argue and substantiate the creation and development of new Fab Labs as a means of supporting innovation (Hart, 2004). Over 700 independent, autonomous projects to open Fab Lab exist around the world, with large concentrations in Western Europe and Asia (Gershenfeld, 2015). These initiatives benefit from the resources of the Fab Foundation, an independent group created by CBA in 2009 that provides documentation, curriculum, and organizes annual Fab conferences. Labs choose to adhere to “Fab Charter”, a document that formalizes the mission and values expected to be present in Labs.

Fab Labs & innovation capabilities

Although there is no authoritative, binding definition of what a Fab Lab is or is not, the Fab Foundation created by CBA describes them as platforms for technical prototyping, learning, and innovation. Core innovation capabilities are implicitly present in the Foundation’s descriptions of Fab Labs; we include the component names in italics for emphasis: Fab Labs provide equipment and software (*resources*), programs to enable entrepreneurship and learning (*processes*), oriented by a global network dedicated to knowledge sharing (*mindset*). Fab Labs also benefit from the notoriety of MIT as a leading academic institution; the majority of Labs receive some form of support from sponsors or government organizations (Gershenfeld, 2015).

Appearances of Fab Labs in academic literature are recent and relatively disparate. Common ground among these diverse viewpoints is found in the notion that Fab

Labs enable, facilitate, accelerate, or democratize innovation in a novel manner by bringing various resources, processes, and mindsets under one roof. Scholarly contributions describe Fab Labs through their positive social and economic impacts (Osunyomi, Redlich, Buxbaum-Conradi, Moritz, & Wulfsberg, 2016; Taylor et al., 2016), knowledge-creation dynamics (Okabe, Matsuura, & Oishi, 2015; Wolf, Troxler, Kocher, & Harboe, 2014), capacity for rapid prototyping (T. Kim & Shin, 2016), and utility in facilitating collaboration in innovation processes (Lhoste, 2015). While we remain cautious about over-analyzing the existing, incomplete portrayals of Fab Labs found in both academic and non-scientific literature, in Table 3 we present examples of resources, processes, and mindset described in Fab Lab literature.

Table 3: Examples of building innovation capabilities of Fab Labs in existing literature

Innovation capability components <i>(Börjesson & Elmquist, 2012; Christensen 1997)</i>	Examples from Fab Lab literature
Resources	<ul style="list-style-type: none"> • Individuals present and interactions while sharing their skills and expertise (Dyvik, 2013) • Professional-grade fabrication tools (Gershenfeld, 2012) • Project documentation (Wolf et al., 2014) • “External” knowledge sources: global network of hundreds of local Labs (Dyvik, 2013)
Processes	<ul style="list-style-type: none"> • Rapid prototyping (Kim & Shin, 2016) • Personal innovation: “making products a market of exactly one person” (Gershenfeld, 2015) • Highly collaborative knowledge creation (Okabe, et al. 2015; Lhote, 2015) • Organizing ad-hoc project teams (Taylor et al., 2016; Wolf et al., 2014)
Mindset	<ul style="list-style-type: none"> • Core values: openness, DIY, collaboration, sharing (Wolf et al., 2014)

Though each element described taken individually is not necessarily specific to Fab Labs, the Fab Lab model brings these components together in a unique configuration. Osunyomi *et al.* (2016) describe this union as “a substantial avenue for all users to transcend the static ideation process into the development of tangible artefacts.” Merino, Rodado, & Alcalde (2015) describe Labs as an ideal setting for “entrepreneurs who are imaginative and creative and need a space and a place and a community to fend for their innovation.” In this sense, Fab Labs are constituted in a way that brings together a set of individually generic capabilities in a structure that enables or enhances innovation by resetting barriers of entry.

Fab Labs in corporate environments

Interest in adapting Fab Labs to corporate settings emerged in the late 2000s. Our research identifies one of the first Labs appearing in 2009 at Areva NP, a subsidiary of a large French industrial firm that specializes in nuclear reactors. Although Corporate Fab Labs do not explicitly adhere to the Fab Charter or label themselves “Fab Labs”, they do share deep conceptual ties.

Like Fab Labs, these corporate structures provide open access to highly versatile, professional-quality manufacturing tools and software (*resources*), programs to facilitate transforming ideas into tangible objects (*processes*), oriented by objectives to increase creativity and innovation (*mindset*). Initial descriptions of Corporate Fab Labs in scientific literature identify their role in increasing innovation capabilities through accelerating product development and exploration processes (Trivery, Masclet, & Boujut, 2015), or organizing resources to enhance collective intelligence (Lo, 2014). More recently, we are aware of firms such as Renault and Saint Gobain that are experimenting with creating internal and external networks of Corporate Fab Labs.

As presently constituted, Corporate Fab Labs are primarily promoted internally by their creators as mechanisms for developing innovative products and services. But practitioners, both creators and users of Corporate Fab Labs, often describe Labs as a proxy for creating specific mechanisms that bring innovative processes, methods, and resources to all functions and divisions of their respective workplaces (Bosqué, Noor, & Ricard, 2014). In other words, they perceive these structures as a means of resetting innovation capabilities within their company.

Thanks to in-depth empirical investigations, we can now contribute to answer three questions:

1. How do Fab Labs contribute to innovation capabilities?
2. What type of reset do Fab Labs perform: single component resets—resource, process or mindset—or a more complex combination
3. Do Fab Labs perform hard or more incremental resets, and using what means?

Methodology

In this paper, we build upon empirical data collected through interviews, visits, and observation of Fab Labs both within and outside of corporations throughout 2015 and early 2016. We used snowball sampling to study 48 Fab Labs or projects to create Labs, principally in France, Japan, and the United States. For the purposes of this paper, we solely focus on data collected from existing and future Labs in eighteen large organizations across ten industries (Table 4). Due to the limited existing research, our study was both exploratory and qualitative in nature.

In order to understand the ways in which Fab Labs directly contribute to the innovation capabilities of firms, our initial studies focused on uses of the Lab in innovative processes—namely prototyping and collaborative product design. As we encountered practitioners’ more nuanced vision of the intended purpose of their respective Labs, we expanded our research questions to look for ways in which Fab Lab’s contribute to or reset innovation capabilities within firms.

Our research sample covers a wide panel of organizations in diverse industrial and competitive contexts and is built upon a series of interviews, observations, and official documents and presentations (Table 4). We started by approaching each Lab requesting an interview with the Lab creator or manager; representatives of eleven Labs responded favorably to our requests. In total, we conducted a series of fifty-one interviews with creators and users of companies. Detailed notes were taken during semi-structured interviews.

Where possible, we observed and participated in the activities of the Lab and conducted interviews of “users” of the Lab. Notes of impressions and observations were recorded during or shortly following Lab visits and open-ended conversations. In the case of five Labs, we were unable to interview with the Lab manager or creator, but obtained official documentation from each Lab which was enriched by accounts from Lab managers at other firms that had first-hand knowledge of these Labs.

We initially analyzed data collected with open coding to identify areas in which Corporate Fab Labs are used to create tools that presently or could one day contribute to building innovation capabilities. We regroup our results and examples of Fab Labs as operators of innovation capability resets using the simple innovation capability framework—resources, processes, and mindset.

Table 4: Summary of Labs studied & data sources

Industry	Company (Parent company)	Year Lab Created	Country	Data sources
Chemical	Air Liquide	2012	France	<ul style="list-style-type: none"> • Interview of a Lab creator • Interview of a Lab employee • Interview of a Lab non-user • Documents and presentations produced by Lab employees
Aerospace	Airbus	2014	France	<ul style="list-style-type: none"> • Interviews of 2 Lab creators • Documents and presentations produced by Lab employees
Electronics	Alcatel-Lucent (Nokia)	2013	France	<ul style="list-style-type: none"> • Documents and presentations produced by Lab employees
Energy	Areva NP (Areva)	2009	France	<ul style="list-style-type: none"> • Lab visit + observations • Interview of a Lab creator
Financial	Cardif (BNP Paribas)	2014	France	<ul style="list-style-type: none"> • Interview of a Lab non-user • Documents and presentations produced by Lab employees
Software	Dassault Systems	2013	France	<ul style="list-style-type: none"> • Interview of a Lab non-user • Documents and presentations produced by Lab employees
Energy	EDF	2012	France	<ul style="list-style-type: none"> • Documents and presentations produced by Lab employees
Software	Evosoft (Siemens)	2012	Germany	<ul style="list-style-type: none"> • Documents and presentations produced by Lab employees
Energy	GRDF (Engie)	2015	France	<ul style="list-style-type: none"> • Interview of a corporate executive • Interview of a Lab non-user
Household appliances	Groupe SEB	2013	France	<ul style="list-style-type: none"> • Scientific paper • Documents and presentations produced by Lab employees
Energy	GRTgaz (Engie)	<i>in creation</i>	France	<ul style="list-style-type: none"> • Interview of a corporate executive • Interviews of 2 Lab creators • Interviews of 11 future Lab users
Retail	Leroy Merlin (Adéo)	2013	France	<ul style="list-style-type: none"> • Interview of a Lab creator • Interview of a Lab employee
Automotive	Nissan	<i>in creation</i>	Japan	<ul style="list-style-type: none"> • Interview with 3 Lab creators
Telecom	Orange	2012 (inactive since 2014)	France	<ul style="list-style-type: none"> • Interview of 2 corporate executives • Interview of 2 Lab creators • Documents and presentations produced by Lab employees
Automotive	Renault	2012	France	<ul style="list-style-type: none"> • Lab visit + observations • Interviews with 4 Lab creators • Interviews with 1 Lab employee • Interviews with 20 Lab users • Interviews with 3 Lab non-users • Interviews with 2 corporate executives • Documents and presentations produced by Lab employees
Electronics	Ricoh	2015	Japan	<ul style="list-style-type: none"> • Lab visit + observations • Interview with Lab creator
Aerospace	Snecma (Safran)	2013	France	<ul style="list-style-type: none"> • Documents and presentations produced by Lab employees
Electronics	Sony	2014	Japan	<ul style="list-style-type: none"> • Lab visit + observations • Interview with a Lab creator • Interview with a Lab employee • Interviews with 2 Lab users • Interview with a Lab non-user

Results & Discussion

This section presents a synthetic description of innovation capabilities identified in the 18 Corporate Fab Labs studied using the basic components of the innovation capability framework: resources, processes, and mindset. We describe elements present in relation to each of the three components individually, and include examples of resource, process, or mindset-oriented reset of innovation capabilities. Although each component is discussed separately, we underline cases of systemic changes, where one component instigates a reset in relation to the others. Finally, we discuss two potential configurations of Labs in terms of resetting innovation capabilities as organizational hybrids and as meta-tools.

Resources

Corporate Fab Labs regroup a number of physical and human resources used in resetting innovation capabilities. We begin by presenting a description of physical and financial resources present in Labs. We then describe the human resources that complement these resources, most notably Lab managers and the community of Lab users that are involved in proposing, organizing, and running Lab activities. Finally, we present examples of resource-oriented innovation capability resets identified through our study.

Physical resources

By definition, Labs have some material resources, such as machines for prototyping, and thus require a physical space. Although all 18 Labs studied have a dedicated space, the location and size vary significantly. The smallest Lab identified is a repurposed storage closet adjacent to the office of the Lab creator; the largest uses 1500m² of a large aircraft hangar. One Lab is placed on the ground floor at the entrance of the company's global headquarters, while two Labs are located next to the company cafeteria. Aside from these singular cases, the majority of Labs are housed in non-descript office buildings rooms ranging from 50 to 200m², the equivalent of a medium to large meeting room.

Within the Lab, physical resources are often grouped in zones oriented towards specific types of activities: designing, making, and networking. In most cases, these zones are in an open-space configuration, although three Labs isolated certain machines in a closed, locked area within the perimeter of the Lab due to noise and safety requirements.

Seventeen of the eighteen Labs have a “designing” zone, with materials to facilitate design processes, enhance creativity, and stimulate the expression of ideas. The Lab without a design zone would like to implement one, but is unable to do so without obtaining a larger physical space. Examples of materials present in the design zone

include giant white board walls, Legos, Play Doh, and other toys. All but three of the Labs had a small library or bookshelf, which in the majority of cases includes books and magazines about entrepreneurship, how-to guides and references for various machines, and innovation in general. All of the Lab managers interviewed described this zone for developing concepts and ideas as a stark contrast to traditional office or meeting room settings, adding descriptive adjectives such as “playful”, “whimsical”, “vibrant”, and “fun”.

Sixteen of the eighteen Labs studied have a “making” zone, with machines dedicated to prototyping such as laser cutters and 3D printers. The two Labs that do not have machines describe themselves as being oriented towards “intangible prototypes” used in creating new services that do not necessitate prototyping machine. This vision is contrasted by two other Labs that focus on service creation that describe an important role of machines to prototype “touch points”—physical elements of the service with which end users have direct contact such as a check-in kiosk.

All but one of the Labs have a “networking” zone, intended to provide opportunities for “serendipitous encounters”, sharing ideas, and getting to know individuals from other areas of the organization. Key resources in this zone are couches and bean bags, as well as coffee machines, refrigerators, and microwave ovens that encourage individuals to drop by during breaks and lunchtime. One Lab manager explained “as useful and interesting as all of our machines are, the coffee maker is probably the most important machine in the [Lab]. It promotes spontaneous gatherings and gives people a legitimate excuse to stop by the Lab frequently for a break.”

Financial resources

Although creating a Lab requires some financial resources, the majority of Lab creators did not perceive a lack of funds as a major impediment to fulfilling their vision of creating a Lab. Eleven of the eighteen Labs sampled obtained funds through a standard project budget request process used within their organization; the other Labs worked with funds from existing operational budgets.

At least three Labs were created with less than \$5,000, excluding leases for some larger machines, which the respective Lab creators described as a challenge that required creative sourcing of tools and materials. Faced with these constraints, one Lab creator in a large multi-national corporation described going dumpster diving to collect scrap wood to build tables and recovering a couch and chairs from a neighboring start-up that disposed of them after buying more luxurious furniture. Another Lab’s budget request was unsuccessful, to which the lab creator said “No money? No problem!” and described how he’d start by creating a mindset for innovation which costs “next to nothing.” Among Labs that obtained financial resources through a budgeting process, one Lab declined the equivalent of a blank check from the CEO with the intent of involving friends and coworkers in painting,

resurfacing the floor, and building DIY furniture in an effort to create “our very own place for innovation.”

Beyond resources for the creation and day-to-day operation of the Lab, a handful of Labs are able to provide financial resources to back the development of innovative products. Four of the Labs studied have specific budgets allocated for incubating innovative project teams, while two others have informal support from decision makers that provide resources to create advanced prototypes related to their organizational responsibilities.

Human resources: The Lab manager & members of the Lab community

Human resources are among the most critical elements in a Lab, most notably the Lab creator or manager and members of the community of Lab users. Eleven of the eighteen Labs sampled have full-time staff dedicated to operating the Lab, with responsibilities such as organizing creativity and brainstorming sessions, machine training and maintenance, and developing relationships between the Lab and other areas of the organization. The seven Labs without a dedicated full-time staff member resort to alternative techniques for managing the space. In one company, the Lab co-creators take turns “telecommuting” from the Lab and take breaks to help interested individuals use available resources. In another company, the Lab creator manages use of the space with room scheduling tools used within the company. Three non-staffed Labs use self-service access, relying on individuals to use common sense and respect basic rules and guidelines posted on the walls. A dozen of the Labs studied also rely upon the contributions of other Lab users to volunteer and propose, organize, and run Lab activities. Examples include formal peer-to-peer training sessions present in at least three Labs and organizing special events to meet other Lab users and share their respective projects.

Resource-oriented resets

Taken as a physical space and entity, Corporate Fab Labs can of themselves be a resource for resetting innovation capabilities. In at least one company, the corporate HR director uses the Lab as part of new employee orientation to encourage employees to take advantage of resources to innovate. In eight organizations, the Lab provides a dedicated, physical setting for pre-existing internal social networks dedicated to innovation. One employee described the Lab as transformative for their online community: “individuals express ideas online and others to reply ‘hey, let’s go try it out right now at the [Lab]!’”

The configuration and tools available in Labs are described by the majority of Lab managers as being “atypical” or a “pleasant change of scenery”. The immediate proximity of the “making” and “design” zones were mentioned by at least five Lab Managers as an important means of encouraging a cycle of rapid iterations and “doing, rather than talking about doing something.” The machines in Labs are

visible, and all Lab managers with prototyping machines in their Lab identified the role that equipment had in drawing individuals in, which in turn stimulates ad-hoc networks of individuals willing to informally participate in “cool”, interdisciplinary projects.

Finally, the Lab can also act as a symbol of doing things differently to innovate—a type of resource that can be paired with an innovation-focused mindset to reset. In this sense, Labs would reset innovation capabilities without needing to ever set foot in one.

Processes

Processes are the means of transforming resources into higher level outputs—in other words, the way of doing things. It is expected that processes in Corporate Fab Labs are generally able to do things differently, since they build upon a unique configuration of available resources and mindset. We describe the processes of creating and managing a Corporate Fab Lab, as well as a look at design processes developed within Labs. We also describe a series of process-oriented innovation capability resets enabled by Labs.

Lab creation as an intrapreneurial process

All of the Lab creators interviewed identified themselves as *intrapreneurs* or institutional entrepreneurs; they equally identified this characteristic as imperative in the process of obtaining necessary approvals, budgets, etc. to create their Labs. Necessary intrapreneurial attributes described by Lab creators include being able to network, solve problems, promote ideas, inspire and support others, stand by personal convictions, and staying optimistic. These qualities are not specific to creating Corporate Fab Labs; two Lab creators suggested that many colleagues used such qualities every day to obtain constrained resources for their projects.

At least five of the Labs studied countered limited firm resources by building their Lab through an emergent, process that relied almost exclusively on personal contributions. In one case, the Lab started in a large storage room as a quirky meeting place for a weekly “idea café” gathering organized by the company’s Innovation & Creativity department where individuals could share and discuss new, innovative ideas. Each week, the event organizer would bring fresh homemade cakes; over time, individuals contributed to the setting for the idea café and brought in tables, chairs, a microwave oven, white boards, Legos, and a video projector. The resulting hodgepodge configuration lasted for at least a year, when a small budget was obtained to acquire the first prototyping machines and some additional needed furniture. Later, the Lab creators identified little known corporate processes that were well suited for obtaining moderate investments, which allowed them to acquire a laser cutter, CNC router, and nearly a dozen 3D printers. Another Lab creator described creating their Lab as an “organic process”, taking nearly two years to

conceive and iterate various aspects of the Lab before starting work on creating the physical space.

Lab management processes

Processes for managing activities within the Lab vary in complexity. Ten of the eighteen Labs studied rely almost solely on ad-hoc project teams to use Lab resources ways they deem suitable for their needs. One Lab manager described this as a natural extension of the DIY mindset, allowing individuals to figure out what works best for their specific needs and goals. Because project teams may work in the Lab at different periods of time, at least five of these Labs used what one Lab creator described as “lightweight, common-sense tools” to avoid conflict in terms of resource availability. For example, one Lab requests that users fill out a slip of paper each time they use the 3D printer. The form includes the name of the individual, their office phone extension, the print start time, and the estimated end-time of the print. If another Lab user happens to notice a problem or deformation in the printing process, it is anticipated that they call or notify their coworker. In another Lab, a user created an internal website to reserve the laser cutter and other machines.

Seven Labs used multiple, parallel processes for managing Lab resources. While each of these Labs offers a selection of “self-service” tools and materials open to all and managed through ad-hoc processes, they also used various processes to identify, select, and manage a limited portfolio of projects that require more substantial resources. Five of these seven Labs use a candidature process to identify projects for incubation, while the other two use steering committees to both suggest and select projects. Most candidature processes require presenting both a basic prototype and a brief “pitch” that presents in less than 5 minutes the concept and most importantly, a plausible use case and business model. These pitches are auditioned and reviewed by a selection committee, composed of company actors such as the Lab manager, project managers, executives, and in some instances outsiders such as high-profile entrepreneurs. Some selection processes present unique criteria, for example one firm specifically calls for and primarily selects proposals for improvements to existing manufacturing processes used by the firm. In two instances, the committee included Lab managers from other companies that looked for opportunities for inter-firm collaboration.

Once projects are identified and selected, we identified three configurations for project incubation: within the Lab, within the firm, and outside the firm. Projects incubated within the Lab, called “sprints” in one Lab, generally have a dedicated project space that houses a team of two to five individuals during a period ranging anywhere from 1 to 6 months. In two firms, projects are incubated as a special task force within existing business units. In the case of three firms, incubated projects are occasionally housed outside the firm. In one instance, a project was housed in the Corporate Fab Lab of another firm to benefit from the expertise telecommunications

engineers present in the other firm. In the other two cases, the Corporate Labs did not have the necessary equipment to create advanced prototypes and housed projects in independent, Fab Lab-like structures such as Usine.IO in Paris or TechShop in the United States.

Only one Lab studied identifies its management as a closed-off process. The Lab is reserved for innovative projects requested and in collaboration with the service provider's clients; employees wanting to use the Lab must obtain authorization from the Lab manager. The creator of this Lab describes this position as both voluntary and necessary: it voluntarily encourages individuals interested in using the Lab to listen to their clients needs and requests to innovate, and was necessary to convince executives of the legitimacy of the Lab. At another moment of the interview, this individual eluded to the fact that in reality, they approve nearly all requests to use the Lab with no questions asked.

Design processes

Fab Labs are configured to encourage rapid iteration processes through cycles that pass from idea generation to prototype making and testing. Iterations are influenced by testing objects and observing their use. To encourage iterative processes, fourteen of the eighteen Labs train and accompany projects using design-oriented approaches such as design thinking and methods based on C-K Theory (Hooge et al, 2014). Although the other four Labs interviewed encourage iterative design processes, they were not specifically aware of these design-oriented approaches but expressed interest in learning more about them.

Process-oriented resets

Although most processes identified through our study are related to activities within the Lab, some emerging examples indicate that Labs can also be triggers for process-oriented innovation capability resets in other areas of the organization. For example, the incubation candidature process in one Lab led to involvement of a HR director looking to identify highly motivated individuals with unique problem solving abilities. In situations where non-employees contributed, even modestly, to the prototype or pitch presented, he adds their names to a pool of high-profile candidates for recruitment.

In at least sixteen of the Labs studied, users identified the Lab as a way of “short-circuiting” company design processes. In one case, an engineer was unable to obtain support from his superiors with a proposed redesign of a small plastic piece that had a high defect rate. His requests were rebuffed since the estimated return on investment was insignificant in relation to the resources the manager thought necessary for the redesign. After repeatedly lobbying his manager over the course of a year, the engineer heard about the company's Fab Lab. After being introduced to the Lab, he spent an hour in the Lab preparing his design for the 3D printer and

brought the prototype to his manager, who “finally understood the value and simplicity of the design when it was in his hands.” The redesigned piece was sent to production after conducting performance tests on a small-series batch based on the original prototype.

Although numerous examples of similar process resets were described in all Labs interviewed, the majority of them are still confronted with the challenge of resetting performance evaluation processes within their respective firms. At least 11 of the firms interviewed explicitly expressed a need for new evaluation processes better suited to innovation and the function of Labs. One Lab creator expressed frustration, stating “my superiors expect me to use the same performance indicators as traditional design projects where almost every parameter is known and pre-defined. In the [Lab name] we work with the unknown. Calculating performance in the same way is like trying to multiply any number by 0—regardless of the size of the effort and resources put in through one part of the equation, the result is always null.”

In contrast, another Lab manager proudly explained that their Lab was “profitable in less than a year and generating over 1.5 million euros in savings per year.” Further questioning revealed that such calculations are possible in situations where the Lab is primarily used to redesign, improve, or enhance existing parts or processes. The Lab manager continued, “We have precise costs on the existing parts or processes and we compare that to estimated costs for the new part or process, multiplied across the number of products we’ve currently sold that benefit from the innovation.” When questioned further, the manager inferred that a reset of evaluation process are needed in cases of more radical or breakthrough innovation.

Mindset

While Corporate Fab Labs have unique configurations of resources that promote alternative processes, all Lab creators and managers interviewed described a creativity mindset as the leading component to enabling innovation capability. As one Lab creator described, in the minds of many individuals being an intrapreneur “...isn’t really possible. We’re here to make the impossible seem possible.” Labs enable a do-it-yourself (DIY) and a do-it-with-others (DIWO) mindset by placing the tools and resources necessary to design, fabricate, and network in a single setting.

The majority of Labs employ a slogan or set of rules to indicate the mindset Lab users should adopt. One Lab uses the slogan “Fail fast. Fail smart. Fail cheap.” Another Lab is named to make reference to a Japanese word charged with the notions of creativity and artisan handcraft. An association of eight corporate Labs in France informally adopted the “Rules of the Garage”, a list of 11 points produced by Hewlett-Packard’s corporate communications department in the early 2000s as part of an internal campaign to promote a more inventive and creative company culture by recalling corporation’s humble origins in a small garage. Rules from this list begin

with “Believe you can change the world,” and include points such as “Know when to work alone and when to work together,” and “Invent different ways of working.”

Mindset-oriented resets

The mindset within Corporate Fab Labs can permeate other areas of the firm and reset innovation capabilities. For instance, in at least 10 firms, Lab users or creators indicated that the presence of a Lab is a sort of reminder or gentle nudge (Thaler & Sunstein, 2009) that employees should occasionally take a pause in their day-to-day activities and take time to create. Lab creators in all firms interviewed also indicated that the Lab is an internal symbol of liberating creativity and innovation.

Although mindset-oriented resets may have to counter deeply ingrained corporate culture, they also need to be carefully measured in terms of frequency and intensity. The rhetoric employed by many Fab Lab creators may also appear quite violent—not just a courteous wake-up call but akin to being pulled from one’s bed and thrown into the battlefield. Expressions employed by all but two of the Lab creators interviewed include “Innovate or die!”, “The barbarians are at the gate!”, the imminent threat of “Uberization,” an allusion to the “death” of the taxi industry at the hands of Uber’s mobile application, or the dangers of not staying at least one step ahead of “GAFA”—an acronym signifying Google, Apple, Facebook, and Amazon.

Such alarmist calls certainly garner some attention, but also run the risk of becoming like the boy who cried “wolf!” In one firm, two employees interviewed had gone to the Lab after hearing one such call to arms by a Lab creator, expecting what they describe as a “state-of-the-art facility” creating the future of their workplace. Both were underwhelmed by the hodgepodge configuration; one of them explained “When I looked in the door, my first reaction was ‘This is it? This is what’s supposed to save our company from the future? We’re doomed.’”

More frequent, moderate mindset-oriented resets can be renewed frequently. One Lab creator admitted to using similar alarmist expressions at one point, but found that it was too intense as it accused the organization—and indirectly its employees that he wanted to motivate—of being the authors of “what seemed to be inevitable future failure.” Now he regularly reminds others that “our intent is to learn how to do things differently, and maybe one day to do things better than we know how to today.”

Corporate Fab Lab as organizational hybrids: places, but also levers

Corporate Fab Labs should effectively enhance innovation capabilities, as they contribute new resources, new processes, and new mindsets. Such contributions in and of themselves are not exclusive to Fab Labs; existing literature describes

externalized corporate settings that make similar contributions, such as creating external entities or subsidiaries dedicated to managing innovative projects, or forming autonomous project teams or internal task forces detached from the corporate structure for the same purpose (Wheelwright & Clark, 1992). Although all three configurations enhance innovation capabilities, external entities and internal-and-detached taskforces do so in an independent, additive fashion. Such contributions could be formulated as an equation as follows:

$$\text{Total Innovation Capabilities} = \begin{array}{c} \text{Corporate innovation capabilities} \\ + \\ \text{Capabilities developed in a detached entity} \end{array}$$

In other words, these entities are not intended to change innovation capabilities of the core structure, which remain the same, but rather develop and accelerate more radical innovations in a detached entity.

Corporate Fab Labs have a very different mindset: 100 % of the Corporate Fab Labs managers we have interviewed have the ambition to not only catalyze corporate innovation capabilities, but to infuse the whole organization as an innovation model. Corporate Fab Labs hence aim to combine the classical role of internal change agents—the role of an innovation department, for instance—and the role of creating a setting open to possibilities. By such settings we suggest that innovation capabilities would be guaranteed a free expression not only within the Fab Labs themselves, but also following the transition from the Lab back to to “business as usual”.

Such contributions take time to cultivate. Reflected as an equation, contributions at an early stage of Fab Lab development would be nearly identical to the contributions of detached entities for innovation:

$$\text{Total Innovation Capabilities} = \begin{array}{c} \text{Corporate innovation capabilities} \\ + \\ \text{Fab Lab innovation capabilities} \end{array}$$

However, as the Lab starts to develop surplus capabilities, an intermediary equation for total innovation capabilities would emerge:

$$\text{Total Innovation Capabilities} = \begin{array}{c} \text{Corporate innovation capabilities} \\ + \\ \text{Fab Lab innovation capabilities} \\ + \end{array}$$

Surplus innovation capabilities
transferred from the Fab Lab into
other corporate innovation processes

In later stages, several configurations could be imagined. One consists of multiplying corporate Fab Labs so that each part of the organization has its own Lab. This is an emerging tendency we observe in several companies. Another tendency observed is the creation of communities of Labs within multiple firms, exchanging not only best practices and support, but ad-hoc collaboration on product development projects and innovative managerial practices. Another advanced configuration would be the disappearance of Fab Labs as distinct, physical settings following a total integration of the Lab's resources, processes and mindset. In other words, the whole company would become a giant Fab Lab.

Corporate Fab Labs as meta-tools

External or internal-and-detached structures generally work on a project management mode: the setting is defined for the purpose of a given project. Corporate Fab Labs are different: they are places where various activities and outputs—including projects—can emerge. In the logic of Fab Labs as defined by Gershenfeld, one can use them to “make (almost) anything”. There are no predefined projects but rather a near-boundless realm of possibilities, structured by a combination of machines, community and imagination. The only barriers or rigidities (Leonard-Barton, 1992) that could remain would be organizational routines unconsciously imported from prior corporate experiences and embedded culture.

Because corporate Fab Lab users are also employees, being active in a corporate Fab Lab goes against the grain in relation to existing corporate rules and processes. Corporate Fab Labs restore direct access to machines, free community building and open use of imagination. In other words, they represent a reset of existing innovation capabilities: resources, processes and mindsets.

A “reset” can infer restoring default parameters from a specific point in time. In this sense, resetting innovation capabilities could mean that a given structure has, over time, derived from its initial objectives, functions, and outputs, and should be restored to its initial form in terms of organizational structure, tasks, responsibilities, design and decision processes, etc. However, Corporate Fab Labs represent a different, more fundamental kind of reset. They're not a reset to the initial organization chart, but rather a reset to the core elements of an organization: just people, places, machines, and a handful of principles (DIY, community building, having fun, failing often, fast and smart) for giving birth to emerging, unprecedented activities: a reset to the basic grammar of organizational life.

Managerial implications & conclusion

Building innovation capabilities is a critical, but often misunderstood managerial activity in firms where innovation is of strategic importance. Although significant research exists demonstrating ways to enhancing existing or build new innovation capabilities, in this paper we demonstrate through our research of Corporate Fab Labs that innovation capabilities can also be reset. Fundamental resets identified in Labs include a DIY-attitude which bypasses procedures for obtaining resources, a community-focused reset that leaves standard working processes behind while building a new network resource, and a mindset that puts “having fun” on a much higher register in the workplace. For managers faced with constraints that appear to hamper innovation, the concept of resetting capabilities can be particularly useful.

First, resets affirm that it’s possible to build innovation capabilities using the resources, processes, and mindset that are “on hand”. Although some Corporate Fab Labs studied were described by their creators as being well-funded, the majority of initiatives to create a Lab simply worked with what was available, taking advantage of opportunities as they appeared and adapting to challenges stemming from other areas of the firm. Such an approach may take several years before obtaining formal praise and recognition from executive management, as was the case with at least two of the Labs studied.

Similarly, resets can be adapted or oriented specifically towards one of the three innovation capability components—resources, processes, and mindset—and induce an indirect reset of the other two components. As one Lab user indicated, this approach is the equivalent of “hacking the organization, but in a good way.” Managers wanting to create a Fab Lab but lacking in resources could start by building a do-it-yourself mindset amongst peers that over time could gather resources and create new processes.

Finally, although resets can free or generate innovation capabilities through new configurations, managers need to modulate their spread, intensity, and frequency. Initial indications from our research suggest that this modulation is little more than a process of trial and error. We anticipate performing continued research of innovation capability resets to identify specific categories and types of resets best suited for a variety of organizational contexts.

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— Article n° 2 —

*“Making nothing or something:
corporate Fab Labs seen through their objects
as they cross organizational boundaries.”*

Matt Fuller & Albert David, 2017

Making nothing or something corporate Fab Labs seen through their objects as they cross organizational boundaries

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Abstract

As large firms pursue their quest to support NPD and fuzzy front-end activities within their organizations, some have recently opted to create “corporate Fab Labs”. These spaces, which regroup an innovation-oriented community and provide any employee with a physical setting and open access to digital fabrication tools are also the birthplace of objects. A lingering and recurring question among practitioners and decision makers is: what do these objects represent? In terms of innovation, are they something, or nothing?

This paper is an initial response to these reactions and develops a theoretical and empirical study of objects made in corporate Fab Labs. Building upon empirical data collected from a series of photos, we contribute a rudimentary tool for identifying the maturity of corporate Fab Labs as their objects cross three organizational knowledge boundaries: syntax, semantic, and pragmatic.

Introduction

Fab Labs describe a type of small-scale “digital factories” that strive to promote learning and enable creativity by bringing together tools, machines, and people (Gershenfeld, 2005; Walter-Herrmann, 2013). Created as an educational outreach program 2001 by MIT, activities in Fab Labs are centered around fabrication of various objects and the ability to “make (almost) anything” (Mikhak, et al. 2002). The Fab Lab concept was recently adapted to corporate settings in over twenty large multi-national organizations, often as a means of stimulating innovation and creativity within firms (Fuller, 2017).

In most organizations, it is anticipated that some unique or original objects initially created in a corporate Fab Lab could be further developed through a firm’s product development processes. Corporate Fab Labs are described by their creators as a different approach to the initial stages or fuzzy front-end (FFE) of new product development (NPD) that “breaks down silos” or “creates neutral ground.” Creators of Fab Labs distinguish their initiatives from traditional configurations for front-end product development (Khurana & Rosenthal, 1998) by eliminating at least two types of organizational boundaries. First, from an individual standpoint, Fab Labs are intended as places where individuals temporarily put aside their traditional organizational roles to collaborate with others to create innovative objects. In this sense, individuals traverse a knowledge boundary (Carlile, 2002) as they are exposed to and can resolve issues that typically fall outside the bounds of their functional expertise. Second, from an organizational standpoint, Fab Labs differ from most corporate functions that are composed of a group of individuals with specialized knowledge in one area to operate efficiently.

To identify to what degree corporate Fab Labs are boundary-crossing agents in a NPD context, the present article builds upon a basic research question: do the objects made in Fab Labs reflect, encourage, and create that boundary-crossing agency?

To answer this question, this paper presents an exploratory study of objects produced in four different corporate Fab Labs, and is structured in five sections. The first section presents relevant literature surrounding objects, organizational boundaries, boundary objects and the position of Fab Labs in a NPD context. The following sections then present the methodology used for this study, followed by a presentation and discussion of the empirical results. Finally, the concluding section suggests future research paths and managerial implications.

Literature review

Although Fab Labs are beginning to gain attention from various research fields, proposals of a theoretical framework for analyzing objects made within Fab Labs are absent from scientific literature. This section of the paper contributes a modest, preliminary proposal for an object-oriented theory structured in three main parts. The first portion briefly

describes objects in general, and builds a case for the validity of interpreting the organizational impact of Fab Lab-like structures through object analysis with a general theory of the existence of technical objects. The second portion of the review describes objects in a NPD context as they traverse three types of organizational boundaries. The final portion examines the state of extant Fab Lab literature, identifying descriptions of types of objects. A conclusion summarizes the previous three sections and details the framework used in the empirical analysis section of this paper.

Studying objects in a NPD context

For the purposes of this study, objects are broadly considered as artefacts that are manipulated to achieve a result. Examples of common objects in corporate settings could include tools, machines, raw materials, databases, production schedules, and financial reports. Gilbert Simondon's (2012) general theory of technical objects describes the ability of objects to continuously change state to reflect their surroundings or "*milieu*". As such, the state of objects changes as they are created, made, manipulated, used, and abandoned as they progress towards a specific result.

Objects are made unique through a series of events that take place in a given *milieu* and vice-versa. This holds true, even in situations where objects are materially identical but found in different settings. Given the context of front-end product development, objects become interesting when they are associated with novel or expansive properties (Hatchuel & Weil, 2003) or increase in sophistication. The notion of sophistication does not speak to the technical complexity of an object, but rather the way in which objects evolve as they are introduced to new actors (Simondon, 2012). Put differently, sophistication comes as an object shapes and is shaped new knowledge.

Studies of objects can focus on both singular objects and collections of objects. In the former instance, studies of a specific objects may become "textbook cases" in which both an object and its *milieu* are examined in great detail. These studies frequently build on a single case to illustrate particular situations of success or failure, such as the collapse of the Tacoma Narrows Bridge (Billah & Scanlan, 1998) or the commercialization of an innovative product by Sony (Wood & Brown, 1998). In the latter case, studies of collections or types of objects can indicate processes used in a local setting, such as von Hippel's (1976) study of 111 innovations produced by a single firm.

Some objects found in NPD literature are similar to objects typically made in Fab Labs, most notably prototypes (Ben Mahmoud-Jouini, et al., 2014). In addition to physical properties used in testing, prototypes help construct a dialogue between multiple actors around a single object (Bogers & Horst, 2013; von Hippel, 1976). Not only is this dialogue a crucial part of the construction of a sophisticated *milieu* surrounding a prototype, it also signals a situation in which organizational boundaries may be crossed.

Organizational boundaries & boundary objects

Organizational boundaries exist as a means of handling complexity within organizations (Nonaka, 1994) by creating smaller groups. Each group has a certain level of autonomy, influence, resources, and identity in relationship to the organisation to accomplish their role (Santos & Eisenhardt, 2005). One natural consequence of boundaries is that various competencies develop their own specialized way of discussing, approaching, and resolving problems with objects. Despite these fundamental differences between each functional entity, some objects within organizations can be structured to cross boundaries and efficiently communicate information to all parties concerned. A single object, such as a production planning schedule, can be used across functions for employee scheduling, payroll, purchasing, and sales (Carlile, 2002).

However, organizational boundaries are a significant hurdle in NPD. Developing novel objects stretches existing knowledge (Reid & de Brentani, 2004; Le Masson, Weil, & Hatchuel, 2010), representing a type of organizational curveball that each function must apprehend and interpret. In his empirical study of over 106 cross-functional events in a NPD context, Carlile (2002) identifies three types of boundaries that must be overcome: syntax, semantic, and pragmatic. Each of the three boundaries are briefly presented and serves as the foundation of the theoretical framework used in the analysis section.

Syntax boundaries originate from theories of digital communication. They describe the ability to reliably transmit and receive information using symbols—a type of common language (Shannon, 1949). Although effective communication is considered a determining success factor in organizational innovation (Damanpour, 1991) and in NPD activities (Katz & Tushman, 1981), the ability to communicate may break down as new objects are introduced (Carlile, 2002). Objects crossing syntax boundaries help create a common language, such as a prototype that initiates dialogue between organizational functions (Bogers & Horst, 2013).

Semantic boundaries describe situations in which different meanings are derived by objects, despite the existence of an established language or syntax. Successfully crossing this boundary implies that both parties are capable of using commonly understood terms to discuss objects (syntax) but also interpret objects (semantics). In other terms, successfully crossing this boundary instills a sense of “mutual understanding” (Nonaka, 1994). In this sense, a prototype can help identify respective challenges for future production processes, intellectual property protection, or creating effective sales materials.

The last type of boundary—pragmatic boundaries— are crossed as specific problems introduced by novel objects are resolved. Reaching this point in boundary-crossing requires identifying and overcoming syntax and semantic boundaries (Carlile, 2002). Objects that overcome pragmatic boundaries provide a substrate that can be collectively

altered and reshaped in a problem solving process while incorporating specific knowledge held by each organizational function.

Creating objects that effectively cross organizational boundaries is not the only solution. Several established management practices are intended to reconcile the firm's dependence on organizational functions while mitigating the effects of boundaries in the fuzzy front-end, including the use of autonomous task forces (Wheelwright & Clark, 1992) or cross-functional project teams (Fredericks, 2005). Empirical evidence underscores the utility of these approaches in NPD settings (Patanakul, Chen, & Lynn, 2012), they do not necessarily eliminate organizational boundaries. Often, the effects of such boundaries are simply felt later on. In the case of autonomous project teams, functional boundaries are transformed into project-team boundaries. In the case of autonomous project teams, team members retain their role as a representative of a specific function. To the best of our knowledge, management practices in scientific literature do not describe configurations that temporarily blur out organizational functions.

Crossing boundaries in Fab Labs

Little research exists regarding Fab Labs in a corporate context, leading us to rely upon descriptions given by practitioners in over ten corporate Fab Labs. This data was obtained during the same period as the data collected for the present research (Fuller, 2017). In most cases, Corporate Fab Labs are positioned on the edge of traditional organizational boundaries and core functions. They also sit on the edge of individual boundaries, in the sense that all Labs studied encourage using available resources for personal projects. This position is voluntary, and builds upon similar values presented in Fab Labs such as the Fab Charter (MIT Center for Bits & Atoms, 2007).

Unlike most cross-functional activities in firms where each stakeholder remains distinctly associated with an organizational function (e.g. Tina from corporate communications), “using a Fab Lab” is not a functional responsibility. In addition, although Fab Labs provide the technical means to “make (almost) anything” (Gershenfeld, 2005), corporate Fab Lab managers all underline the importance of getting objects to mature outside the Lab using a portion of the firm's existing NPD methods and resources. As such, using corporate Fab Labs can result in a bi-directional boundary-crossing process: employees first cross organizational boundaries as they temporarily put aside their functional responsibilities and discover and use the Fab Lab. As they return to their workspace, they are able to bring objects back from the Fab Lab, and vice-versa. The following section analyses to what extent objects made in Fab Labs reflect and promote boundary crossing.

Methodology

The present study builds upon a visual analysis of over 500 photos taken over the course of multiple visits in 2015 and 2016 to four corporate Fab Labs in four different

multinational corporations. While Fab Labs are relatively recent, the sample contains one lab created each year between 2013 and 2016. Two labs studied are located in France, while the other two are in Japan.

Photos taken during these visits were sorted to eliminate duplicates, and individual objects created in the Fab Lab were then systematically identified and verified using N'Vivo data analysis software. This process resulted in a sample of 137 objects created by various individuals within Fab Labs. Each object was attributed a unique identifier, accompanied by a brief text describing the object and, where possible, the names of individuals that made the object. A number of descriptive properties were coded in relation to each object: the Lab in which it was created, the machines used, whether the object was intended for personal or professional use, whether it was designed by an individual or a group, and whether the object was made by its designer.

With these descriptive variables established, we set out to analyze each object and determine the types of boundaries they crossed. To do this, we used notes taken when object makers described their creations and wrote a short phrase summarizing the individual's underlying objectives when creating each object. Syntax boundaries represent a common language, or the creation of this common language. Objects that reflect or communicate the first steps of using a Fab Lab are indicative of a syntax object, where examples of descriptions by creators include "Can I really just come and use this machine?" and "Hey look at what I made!". Semantic boundaries build upon this common language as individuals try to learn how they can effectively use the resources Fab Labs provide. These types of boundaries are reflected by descriptions such as "There's a new machine, so I'm going to try to work and see what it can help me make," or "How are we all going to work together on this?" Pragmatic boundaries are crossed when both the Lab and another organizational function work together to solve problems. Descriptions reflecting these types of objects include "we have a problem to solve and know how to solve it here.", and "I'd like to see what my drawing looks like for real, then use it to work with others".

While aggregating this descriptive data, a latent variable emerged that describes the direction in which boundaries are crossed: a type of pull dynamic where organizational functions turn towards the Lab to create objects, in contrast to a push dynamic in which objects are created in the Lab and then presented to an organizational function. This division appears based on the fundamental differences in knowledge required between working in a Fab Lab and working in a specific department of a large firm. In other words, the knowledge necessary to create objects in a Fab Lab and participate in a Fab community is not necessarily the same when working as a mechanical engineer or systems analyst. Recent theoretical lenses from other disciplines such as marketing appear to support this viewpoint (Moreau, Bonney, & Herd, 2011; Mochon, Norton, & Ariely, 2012), however the exploration and use of these alternative frameworks falls outside of the scope of the present study. These directional variables are respectively

labeled throughout the rest of this paper in relationship to the Fab Lab as “inbound” and “outbound” for simplicity.

The two variables—boundary type and direction—were crossed, and each object was systematically categorized in terms of each variable. The framework used to classify objects both in terms of which boundaries are crossed and in what direction is summarized in Table 1.

Table 1: object coding framework (based on Carlile, 2002)

Boundary crossed	Inbound From the organization into the Lab	Outbound From the Lab into the organization
Syntax boundary	<i>Discovering and representing the ability to create (almost) any object</i>	<i>Communicating the existence of the ability to create (almost) any object</i>
Semantic boundary	<i>Putting syntax to the test: learning how to use resources available in the Fab Lab</i>	<i>Learning how the organization will react to proposals originating from the Fab Lab</i>
Pragmatic boundary	<i>Working to resolve problems encountered in NPD projects using resources in the Lab</i>	<i>Using the Lab as a means of proposing and developing projects that will enter the NPD cycle — a part of the “fuzzy front-end”</i>

Finally, we controlled for differences between types of objects within each category by comparing the other descriptive variables, resulting in the creation of two additional, complementary categories: objects created exclusively by Lab workers for use within a Lab and objects crossing boundaries in multiple directions. Objects created for use within the Lab were set aside from the core dataset and described separately, as they are not specifically intended to cross an organizational boundary. This resulted in a total of 103 individual objects. Representative objects of each category are presented and discussed in the following section.

Results

Results are presented generally in this section, followed by specific descriptions based on the type of boundary crossed: syntax, semantic, pragmatic. These boundaries are considered successive and increasingly complex in terms of their surrounding *milieu* (Simondon, 2012). In other words a semantic boundary cannot be crossed without common syntax, and a pragmatic boundary cannot be crossed unless there are shared

semantics (Carlile, 2002). Table 2 resumes the number of objects identified by boundary type and direction.

While there is a relatively even distribution between the three boundary types as a whole, the majority of objects are created by crossing from an organizational function into the Fab Lab. Although fewer objects originating from corporate Fab Labs across boundaries into other organizational functions, outbound objects are generally more complex in nature. In the following sections, we discuss objects surrounding each boundary type. A representative sample of objects—including images—are presented, starting with **inbound** boundary objects and followed by **outbound** boundary objects. Additional relief is provided by reintegrating some descriptions drawn from interviews of the object's creators. We then present two subsets of specific boundary objects: **round trip** objects which originate from an organizational function, enter the Lab, and return to an organizational function, and observations drawn from non-boundary objects created for use within the Lab. Finally, we present a general discussion regarding all objects studied.

Table 2 : Distribution of objects by boundary and direction of boundary crossing

	Inbound From the organization into the Lab	Outbound From the Lab into the organization	'Round trip' objects	Total
Syntax boundary	28	7	0	35
Semantic boundary	28	1	0	29
Pragmatic boundary	12	14	13	39
Total	65	22	13	103






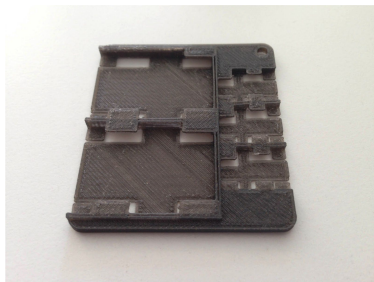
Syntax boundary objects

Syntax boundary objects help establish a common language across boundaries. Inbound boundary objects are used to understand the potential uses offered by Fab Labs. Although some objects created are imagined wholly by the individuals using the Lab, most are replicas created using CAD models available to download on the internet. The examples found in figure 1 are a representative sample of these types of objects. Inbound objects stay primarily within the Lab, acting as a material attestation to knowledge created as individuals adopt the Lab's syntax centered around fabrication—a means for showing oneself that creating an object is possible.

Most inbound syntax objects are relatively simple objects based on common NPD performance criteria of quality, cost, and time (Karagozoglu & Brown, 1993). In other words, they are basic, quick, and inexpensive to produce. Notwithstanding, these objects


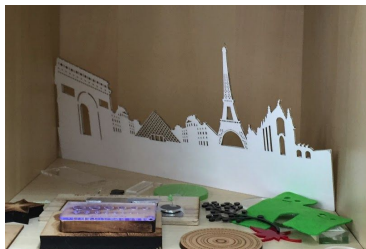

appear to suffice as a means of crossing initial syntax boundaries, as individuals either quickly move on create more sophisticated boundary crossing objects or simply do not return to the Lab. In the latter case, one could legitimately question whether the individuals in question truly crossed a syntax boundary or simply went on the organizational equivalent of a visit to a foreign language speaking country returning home with little more than a souvenir.

Figure 1: sample of inbound syntax boundary objects

		
3D printed version of Robert Indiana's LOVE	3D printed elephant from Thingiverse.	Statue of liberty printed with a 3D printer.
		
Small plastic craft with Mario in pixel art.	Resin 3D print test object.	Electrical fuse holder for a vehicle from a 3D printer.

Nearly 80% of syntax-boundary objects are inbound-oriented. Outbound-directed syntax objects appear to be a bit different in nature. They are more costly and time consuming to produce, and of a noticeably higher finished quality. This may be because they are frequently used to communicate the creative potential afforded by a corporate Fab Lab throughout the organization. Figure 2 provides an example of these types of objects.

Figure 2: sample of outbound syntax boundary objects

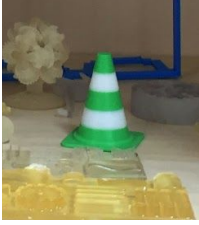


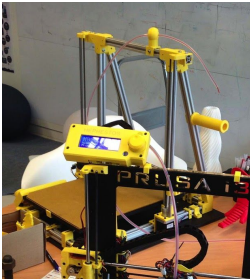


		
<p>3D bust made by a Ricoh engineer of himself using the 3D sense scanner.</p>	<p>Paris "skyline" silhouette made out of cardboard using a laser cutter. Designed as a demonstrator for fun to show the abilities of the laser cutter.</p>	<p>3D printed spire based on an unmodified design from Thingiverse. Produced as a way of showing the benefits of additive manufacturing.</p>

Outbound syntax boundary objects appear to only carry a limited subset of Fab Lab syntax to the organization. These types of objects tend to be more complex and detailed than inbound syntax objects, typically involving some form of design work undertaken by the object's creator. Instead of representing the acquisition of a new organizational language or grammar, as is the case with inbound syntax objects, they convey a type of result or "ends" (Carlile, 2002) that is possible to obtain through using a corporate Fab Lab. One object creator described this as demonstrating to colleagues "the existence of the possibility to do things differently."

Semantic boundary objects

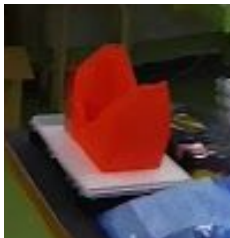
Once common syntax is established, objects can begin to cross semantic boundaries. Although Fab Lab's basic syntax suggests that anyone can come and try to make an object, semantic boundary objects are the emerging result as individuals put that syntax to the test. Figure 3 presents an examples of common inbound semantic boundary objects. Inbound-directed objects are a common result of experimenting with and learning how to use available resources, representing 43% of all inbound-oriented objects in the study.

Figure 3: sample of inbound semantic boundary objects

		
<p>Two-toned traffic cone printed with a 3D printer to demonstrate the possibility of mixing colours in the production process.</p>	<p>Raspberry Pi and Arduino projects made by Lab users.</p>	<p>Laser-cut magnetic chess board with 3D printed pieces.</p>
		
<p>Homemade 3D printer based on open-source (RepRap) plans and modified using CATIA to be able to print large-scale objects.</p>	<p>Abstract man sitting beneath a plastic tree drawn as a means of trying out the 3D pen.</p>	<p>Arduino robotics controller made for a personal project.</p>

Inbound objects used to learn how resources available in corporate Fab Labs can be used are relatively common. However, objects used to learn how the organization outside of the lab would react to proposals made from the Lab were uncommon, with a single occurrence identified pictured in figure 4.

Figure 4: lone outbound semantic boundary object identified in the dataset

	<p>A set of goggles made as a low-cost 3D virtual reality headset that could be paired with the spherical photos taken the company's 360° digital camera.</p>
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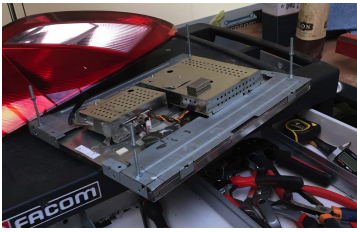

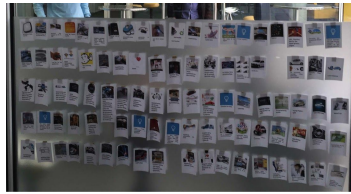
This singular object was created by a group of engineers and designers in the Fab Lab as a means of testing how various organizational functions would react to a new proposition stemming from what they described as a “marginal entity”. As the VR goggles circulated amongst sales, marketing, and various engineering teams the team described feeling a noticeable increase in legitimacy and the ability to move on to new, more sophisticated proposals.

Other factors may explain the absence of outbound semantic objects, namely the existence of prior knowledge and the presence of defined cross-functional processes involving the Lab. The first case recognizes that individuals that use corporate Fab Labs are full time employees of other organizational functions. As such, they may feel that they possess sufficient knowledge to introduce an object originating from the Lab to any given organizational function, allowing such individuals to directly work with pragmatic boundary objects. In the second case, one Lab decided to put in place a program that helps object creators bring their proposals to various organizational functions. Finally, in some instances individuals crossing organizational borders to come into the Lab may not want their work to cross back into an organizational context. This position was suggested by at least three object creators working at one company.

Pragmatic boundary objects

Pragmatic boundary objects provide a means of solving problems across various organizational boundaries. Pragmatic boundaries are the closest to professional applications. The objects in figure 5 provides a representative sample of inbound-oriented pragmatic boundary objects.

Figure 5: sample of inbound pragmatic boundary objects


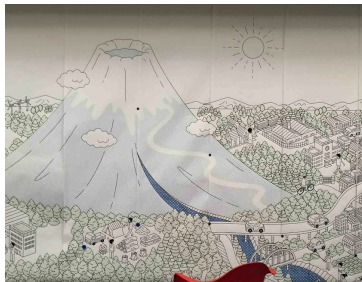

		
<p>Display system from a vehicle. Small pieces and hardware have been added for mounting points. Later on, the engineer hopes to adapt the software for a more interactive experience.</p>	<p>Mounting stand for a selfie stick, drawn in 3D modelling software and made with a 3D printer.</p>	<p>Wall of concepts/ideas produced in a Lab competition.</p>

Inbound pragmatic boundary objects appear to be the result of individuals looking for an alternative solution to problems identified in their day-to-day work. For instance, the vehicle display system example is the result of an engineer trying to test new applications who wanted to fully understand the user experience by mounting the display in a car, but unable to do so using the tools available at his workstation. Once the experiments using the prototype were concluded, the system was left on display in the Fab Lab, while the results were carried back into the employee's day-to-day work.

Outbound pragmatic boundary objects vary substantially in degree of complexity in terms of the surroundings or *milieu* that contributed to their realization. The sample presented in Figure 6 shows objects that become progressively more complex, ranging from a suggested object sent back to an engineering team to a full-scale product launched in the Japanese market.

Outbound pragmatic objects are rarely the result of a single person. Generally, they are proposed by a small team to corporate decision makers who provide resources to continue developing the object within the firm's existing NPD processes. While the objects created in the Lab may be little more than a preliminary version of a basic concept, they are the seeds of discussion that germinate and take root in other organizational functions. The nature of these objects leads us to consider corporate Fab Labs as entities capable of meaningfully contributing to a firm's front-end innovation processes.


Figure 6: sample of outbound pragmatic boundary objects

		
<p>Mounting plate from a vehicle used for acoustics testing.</p>	<p>Prototype feedback surface. The 360° flashlight concept is revisited to interpret the beacons on which the image is shined on to project specific content.</p>	<p>Sony FES smartwatch on display in a central Tokyo train station, the result of a nearly identical outbound object a product developed in the company Fab Lab and now commercialized as a company product.</p>

Internal Lab objects

A specific object that technically does not cross organizational boundaries are objects created in the Lab, for the Lab. A total of 34 objects in our sample of 137 identified fit this criteria. These internal objects, which can be seen in Figure 7, are often created by the individuals that manage the Lab.

Figure 7: sample of objects created for the Lab






		
Custom workbenches constructed using supplies purchased at the store.	RFID badge access used to open the Creative Lab for trained individuals.	Custom brand stamp "Fabriqué au 3e Lieu" made with a laser cutter.

Although these objects are reserved for internal use, they can cross rhetorical and ideological boundaries and help bridge the gap between the Lab and other organizational functions. One of the creators of the benches explained that “showing that everything is made here, by us, makes us appear more legitimate for other areas of the company.” These objects are also frequently used for demonstration and training purposes, allowing individuals arriving in a Lab for the first time to begin crossing inbound syntax barriers for themselves.

Round trip objects

Some objects crossed multiple boundaries, originating from the organization towards the Lab and then emerging and returning back to organizational functions to continue development and progress. These are some of the most sophisticated objects because their existence depends heavily upon a rich network of individuals and organizational functions, as displayed in Figure 8.

Figure 8: sample of round trip objects created using the Lab

		
Custom case for 360° camera drawn using 3D modelling software and printed with the 3D printer	Piece for mounting upholstery on the back seat of a car. (yellow portion)	8-arm 3D printed object made by a Lab member for a children's educational course on fabrication
		
Wena smartwatch, mixing a mechanical movement and the electronics portion in the wrist band	Inauguration lettering prepared and placed by company CEO on Lab entrance	Aromatic essential oils diffuser

Two primary types of use cases for round trip boundary crossing objects emerge: using the Lab to complement existing NPD processes, and using the Lab as a major component of the firm's fuzzy front-end strategy.

Corporate Fab Labs are in some ways able to complement existing NPD processes, granting individuals the ability to test their designs and in some cases obtain alternative resources. This approach is identified in two of the four Labs studied, and includes the camera case and upholstery clip examples in Figure 8. In the case of the latter object, a company engineer identified that one half of the upholstery mounting mechanism frequently broke during assembly that he had designed a year prior. This individual recognized the source of the error had an idea for a more solid mechanism. However, despite repeated requests, his superiors would not adjust his workload to grant him the time needed to redraw the piece, claiming the relative gains would be marginal. Upon discovering the Lab, the engineer decided to find the time to draw up his new proposed mechanism and take the finished prototype made with a 3D printer to his boss. With the piece in hand, his boss was convinced and the new part was sent to production, resulting in several thousands of euros worth of savings. Such examples become more frequent as

individuals are aware of a Lab, learn its syntax and understand its semantics, and finally arrive with specific problems to resolve from their day-to-day workload.

In the case of one firm, the Lab opened up the company's fuzzy front-end processes by using the Lab as an open entity for idea genesis, selection, opportunity identification and analysis (Koen, et al., 2001) under one roof. While it is not the exclusive channel used by the company for front-end development, it constitutes a significant portion of new ventures within the company. As one Lab observer noted: "This is not about turning any single startup idea like [Lab project name] into a gigantic business, but a gigantic business learning how to come up with lots of new, promising ideas." This type of Lab functionality is arguably more complex to initiate than the prior configuration that simply supports existing NPD processes, as it involves creating new tools for idea selection and tight integration with other organizational functions.

Additional examples from our sample underlined two unique cases: creating a symbolic object and an external boundary object. The first case stems from the preparations that took place prior to the inauguration of one corporate Fab Lab. The company CEO, who was instrumental in the creation of this space, wanted to take the time to use some of the tools that would soon be available to all employees and create a tangible object that would communicate the importance of the Lab. He decided to create the vinyl lettering with the Lab name and operating hours that he would place on the windows just barely outside the Lab. This serves as a highly visible reminder that individuals should break down their own organizational barriers to come down to the Lab and create objects. The second case involves boundaries found outside the firm through a children's educational outreach program. A company engineer wanted to share his passion for engineering with local youth, and decided to use the Fab Lab to create a kit that would interest school teachers around the area. After several months of testing the idea, it became a company sponsored program aimed at promoting educational studies in science and robotics. As boundary objects step out of their corporate surroundings and into a series of innovation-oriented communities, the object will progressively increase in complexity and integrate potentially innovative aspects.

Boundary crossing entities

While a core finding of this research is that objects created in Fab Labs are capable of crossing all three types of knowledge boundaries, our data indicates that the types of objects created in each Lab aren't evenly distributed. While all Labs have the technical ability to create boundary objects in each direction, their *milieu* (Simondon, 2012) must also support the existence of such objects. In other words, the types of objects created can indicate the maturity and sophistication of each Lab. The following section explores the possibility of using objects as a gauge of Lab performance and the research perspectives opened by this view.

Multiple factors contribute to the maturity of a *milieu*, with time being a significant contributing factor to an organizational maturity and development life cycle in general (Mintzberg, 1984; Maier, Moultrie, & Clarkson, 2012). Time allows a Fab Lab manager to create deeper organizational ties; it can also create a sense of stability and resilience. However, it may not be the only factor in the relative maturity of each Lab. Table 3 resumes the distribution of boundary crossing objects on a per-Lab basis, including the year in which each Lab was inaugurated or first opened to employees.

Table 3 : distribution of boundary crossing objects per Lab

Boundary crossed	LabA(2013)	LabB(2014)	LabC(2015)	LabD(2016)	Total
Syntax boundary	5 (14%)	19 (54%)	8 (23%)	3 (9%)	35 (34%)
<i>Inbound</i>	2 (7%)	18 (64%)	5 (18%)	3 (11%)	28 (80%)
<i>Outbound</i>	3 (43%)	1 (14%)	3 (43%)	0 (0%)	7 (20%)
Semantic boundary	6 (20%)	15 (52%)	8 (28%)	0 (0%)	29 (28%)
<i>Inbound</i>	6 (21%)	15 (54%)	7 (25%)	0 (0%)	28 (97%)
<i>Outbound</i>	0 (0%)	0 (0%)	1 (100%)	0 (0%)	1 (3%)
Pragmatic boundary	10 (26%)	16 (41%)	13 (33%)	0 (0%)	39 (38%)
<i>Inbound</i>	2 (19%)	4 (36%)	5 (45%)	0 (0%)	11 (28%)
<i>Outbound</i>	5 (36%)	4 (28%)	5 (36%)	0 (0%)	14 (36%)
<i>Round trip</i>	3 (21%)	8 (58%)	3 (21%)	0 (0%)	14 (36%)
Total	21 (20%)	50 (49%)	29 (28%)	3 (3%)	103 (100%)

While the three principal labs studied created a roughly equal number of pragmatic boundary-crossing objects, the nature of those objects varied across each setting. Lab A, the oldest Lab studied, created a proportionally larger number of outbound objects, suggesting the ability of Lab members to create unique proposals and submit them to other organizational functions for selection and further development. Lab B produced a substantially greater number of round trip objects (58% of all round trip objects identified), primarily facilitated by the presence of a formal idea selection process that allows employees to come to the Lab with their own ideas and progressively transform those ideas into a new position within the company. Lab C demonstrated a relatively even distribution between all three pragmatic boundary types, including a recurring use of the Lab as an extension for tools that were otherwise unavailable at individual workstations. Lab D was inaugurated just a month prior to studies conducted at the end of this field-research phase of this study. Of the 12 objects identified in this Lab, only 3 were boundary crossing objects whereas the remaining 9 were “internal objects” intended for

use within the Lab. Secondary data obtained via follow-up conversations with and social media posts from members of Lab D indicate that their objects are able to cross all three organizational boundaries in all directions.

These results suggest that time alone is not sufficient to provoke increased sophistication, and that objects created in Fab Labs vary based on a Lab's capacity to have increased ties and associations with other areas of the organization. In this sense, the Fab Lab as an entity may be considered an organizational boundary object that permanently crosses multiple boundaries. This interpretation resonates with existing descriptions of Fab Labs in literature (Gershenfeld, 2005; Mikhak, et al. 2002) as a "third place" that sits on the edge of traditional entities. Based on this view, the objects produced in each Lab could be used as an indicator of the Lab's own capacity to cross syntax, semantic, and pragmatic boundaries. As it matures, it can be used more effectively to solve problems, interact with, and evolve to support other organizational functions. The notion of an organizational entity as a boundary object is not yet explored in present literature (Carlile, 2012).

Managerial implications & research perspectives

In addition to the theoretical and empirical construct used to analyze objects created in Fab Labs, this paper also contributes a rudimentary tool for managers of corporate Fab Labs to objectively evaluate and position their Fab Labs. This evaluation, which considers the complexity of boundaries crossed, underlines the individual contributions of each object created in the Lab.

This type of evaluation can be useful both inside the Lab and across the organizational boundaries. Within the Lab, it can guide efforts used to promote the creation of specific types of objects, such as training sessions that encourage individuals to bring their professional projects into a Lab to resolve problems with the help of a vibrant community. Across other organizational functions, these evaluations can help decision makers identify the types of contributions Labs make to NPD activities, including front-end innovation activities.

While these contributions are immediately applicable in practice, one limit to the methods used in this research is the absence of alternative types boundary "objects". Examples of these include creativity methods, training programs, and events created in and around corporate Fab Labs that are difficult to identify through photo analysis. Complementary qualitative data collection and analysis could help refine and better describe the boundary-crossing capabilities created through corporate Fab Labs.

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— Article n° 3 —

*“Fitting squares into round holes:
Enabling innovation, creativity, and entrepreneurship
through corporate Fab Labs.”*

Matt Fuller, 2017



FITTING SQUARES INTO ROUND HOLES: ENABLING INNOVATION, CREATIVITY, AND ENTREPRENEURSHIP THROUGH CORPORATE FAB LABS

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Abstract

Acting on personal convictions that a large automobile maker's ability to innovate was too closed-off and poorly suited for breakthrough innovation, a small team at the main R&D campus decided in late 2013 to create a corporate Fab Lab. Building upon what started as a MIT outreach program called Fab Labs, these spaces, present in over twenty large multi-national firms since 2009, are seen by their creators as an opportunity to increase employees' ability to innovate. Although innovation is a strategic priority in most firms, the creators of these spaces encountered substantial institutional resistance early on due to the different nature of Fab Labs, or in their words trying to fit a "square in a round hole." This paper presents corporate Fab Labs to scientific literature. It proposes a theoretical foundation building on established fields of research in managing innovation capabilities and institutional entrepreneurship. Empirical data collected from the founders of ten Labs in France, Japan, and South Korea is analyzed to test this framework. Findings include unique contributions made by Fab Labs to a firm's innovation capabilities and proposals of complementary research paths.

Keywords: Fab Labs, Innovation, Entrepreneurship, Design management, New product development

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1 INTRODUCTION

In 2014, two employees at French automobile maker's Renault's primary R&D center proposed working together to develop new management tools that could be used in an emerging setting dedicated to enabling breakthrough innovation (O'Connor et al., 2008). Their initiative, called the "Renault Creative Lab", stemmed from their personal convictions that Renault's existing innovation processes were too closed-off beyond of a small group of employees and poorly suited for breakthrough innovation. Their solution, patterned after an initiative that started as a MIT academic outreach program called Fab Labs (Gershenfeld, 2005), intended to be a modest yet visible, open space combining a strong sense of community with freely available advanced tools such as 3D printers and laser cutters available for "anyone in the company to make (almost) anything."

As the Creative Lab project progressed, pressure mounted for the team to interact with and contribute to established corporate procedures and management tools for innovation. Several key decision makers enthusiastically embraced and lauded their ambition to increase innovation capabilities within the company. However, the Creative Lab founders quickly realized that most managers and executives applied the same performance indicators for innovation used within the company—such as the number of patents obtained—to establish whether the initiative was useful in contributing to the firm's innovation strategy. Not only did these measuring sticks put the Creative Lab at a considerable disadvantage by pitting them against robust and efficient R&D processes, they also flatly ignored the different types of innovation capabilities this initiative hoped to establish. Frustrated by these frequent reactions, one of the Creative Labs founder's peers asked, "how can we fit the Fab Lab, a square, into the company, which is more like a round hole?"

The team at Renault was not alone in asking—and working to solve—this ambitious yet fundamental question. At the time, the Renault team was in contact with nearly two dozen individuals or teams responsible for "corporate Fab Labs" (or Labs) established as early as 2009 in other large multi-national firms, many of whom faced similar internal challenges. While each of these Labs have successfully obtained some corporate resources, most have done so by finding corporate sponsors who sympathize with their viewpoints rather than using existing innovation performance benchmarks.

Corporate Fab Labs are new research objects to scientific literature. Beyond presenting these emerging settings, the goal of this paper is to understand what contributions to innovation capabilities can be expected from corporate Fab Labs, and the impact that the process of creating a Lab has on a firm's ability to innovate. To answer these questions, the first part of this paper proposes a theoretical foundation for corporate Fab Labs and their creators. This portion builds upon established research fields that describe how firms can develop capabilities for innovation, and the specific challenges faced by individuals seeking to innovate in institutionalized settings. The second part of this paper tests this theoretical foundation by building upon empirical data gathered from 10 corporate Fab Labs in large multi-national firms to identify the unique contributions of these research objects using a basic typology of innovation capabilities. Finally, these comparisons result in several propositions for future research.

2 LITERATURE REVIEW

The emergence of corporate Fab Labs may be a relatively recent phenomenon, but they are introduced into a complex yet established and well-studied environment. This section initially presents the managerial, organizational, and institutional context surrounding innovation in corporate settings. Innovation capabilities—the fundamental object corporate Fab Labs hope to develop—are then discussed, along with a basic innovation capabilities framework used in later analysis. followed by a presentation of the challenges faced by individuals leading innovative projects in institutionalized settings. Finally, a key question from the association of these two research fields is presented.

2.1 Issues raised by innovation management in corporate settings

Innovation plays a vital, but often understated, part in most corporate strategies (Teece, 2010), resulting in difficult-to-resolve organizational tensions. Many large firms are organized to effectively innovate by enhancing, refining, and optimizing existing designs (Crossan and Apaydin, 2009), such as through R&D departments. These structures are effective in producing incremental innovations associated with an established dominant design (Henderson and Clark, 1990). When organizations are oriented towards

breakthrough or radical innovation activities, structural deficiencies often appear (Hatchuel et al., 2002). These inadequacies do not necessarily indicate organizational incompetence or ineptitude; they typically highlight a structure uncomfortable with managing the inherent uncertainty of breakthrough innovation (Ahuja and Lampert, 2001), or the “fuzzy front-end” of new product design (Khurana and Rosenthal, 1998).

Solutions for resolving these inadequacies present in scientific literature build primarily upon an outcome-based view of innovation activities—what is produced—(Damanpour and Aravind, 2006), and in lesser part innovation as a process—or how it is produced (Crossan and Apaydin, 2009). This focus on outcomes is partially justified, as most definitions of innovation necessitate the exploitation of ideas (Baregheh et al., 2009; Crossan and Apaydin, 2009).

Focusing on what is innovated and how it comes about does not necessarily account for determining factors of innovation, or in other words considering *whether* innovation is possible. In this sense, management has a key role in orchestrating and enabling innovation within their firms (O'Connor et al., 2008). To do so, managers should manipulate organizational levers to develop capabilities for innovation (Lawson and Samson, 2011). Actuating these levers in a way that permits innovation necessitates individuals stepping out of the bounds of the organization's dominant design of carefully defined roles and processes and “doing different things in different ways.” (Francis and Bessant, 2005). However, the very roles that individuals perform within organizations are framed in a way that discourages or inhibits individual agency (Battilana et al., 2009). The following sections present these enabling factors—organizational levers and the managers who control them—through the related theoretical lenses of innovation capabilities and institutional entrepreneurship.

2.1.1 Building innovation capabilities

Innovation capabilities describe an organization's readiness and ability to create and respond to new opportunities (Assink, 2006; Börjesson and Elmquist, 2011; Lawson and Samson, 2011). Building and maintaining innovation capabilities requires mobilizing and “orchestrating (O'Connor, 2008) limited organizational resources (Penrose, 1959). Innovation capabilities are a type of dynamic capability (Eisenhardt and Martin, 2000; Teece et al., 1997), which must be regularly exercised and regenerated in relation to constant changes within and outside of the firm (Börjesson and Elmquist, 2011). Failing to maintain developed capabilities, or simply reinforcing the same capabilities, results in a form of organizational atrophy, which as Leonard-Barton (1992) warns, can devolve into an organizational stumbling block or “rigidity” impeding innovation.

Basic building blocks of innovation capabilities include resources, processes, and mindset (Börjesson and Elmquist, 2012; building on Christensen, 1997; O'Connor, 2008). These three fundamentals, described below, are also used in later analysis. While resources, which includes people, technology, cash, and networks, can be reallocated by managers in almost any configuration imaginable, they are bounded by organizational processes and mindsets (Christensen, 1997). However, organizations are complex systems designed to transform resources and produce consistent results through tightly integrating and enhancing processes, including formalization and bureaucracy (Damanpour, 1991). By design, these processes resist changes that fall outside of their identified purpose (Utterback and Abernathy, 1975). Likewise, an organization's mindset, which goes beyond stated values and culture, are the basic tenants that indicate the firm's priorities and reflected by management decisions. An organization's mindset is naturally resilient to change, as it's the fundamental framework or “compact” that governs interactions between the organization and the individuals who make up the firm (Strebel, 1996). Successfully changing a firm's mindset to embrace long-term innovation strategies and unknown innovation requires persistent, systemic efforts (Dougherty and Heller, 1994), typically over multi-year periods of time (Börjesson and Elmquist, 2011; O'Connor, 2008).

Recent empirical studies of building innovation capabilities, such as Börjesson, Elmquist, and Hooge's longitudinal study of two European car makers (2014), suggest that the constrained, highly competitive environment in the automotive industry encouraged short-term management practices in these firms, leaving little time for reflection and developing innovation capabilities. Dynamic capabilities perform best in malleable organizational settings, and lose their effectiveness when confronted with the pressures of complex processes or diverging mindsets (Benner & Tushman, 2003). Overcoming the aforementioned procedural and cognitive barriers to build innovation capabilities requires individuals willing to exercise individual agency and ‘do things differently’ in an effort to orchestrate institutional change (Kelley et al., 2011; O'Connor et al., 2008).

2.1.2 Institutional entrepreneurship

Institutional entrepreneurs, initially described in scientific literature by DiMaggio (1988) as ‘organized actors with sufficient resources’ who see ‘an opportunity to realize interests that they value highly,’ are agents of change capable of building institutional innovation capabilities (Börjesson et al., 2014). By substituting or adapting institutional mindset with a set of personal values, institutional entrepreneurs “disembed” themselves by allowing themselves to do things differently. One indicator of disembeddedness is the acquisition or creation of resources that enable actors to exercise agency. Examples include constructing discursive strategies and rhetoric (Zott and Huy, 2007), or seeking and obtaining backing from institutionally legitimate, embedded actors.

Early literature often portrayed institutional entrepreneurs as heroic figures (Garud et al., 2007) or “mavericks” (Pinchot, 1985) who go beyond the bounds of their institutional roles. However, more recent research acknowledges that institutions are a setting of stability and familiarity, composed of potentially useful enablers and constraints for innovation. One key, established, institutional enabler and constraint is management. Managers are actors with specific institutional roles that reinforce and maintain existing processes, rather than imagining new ways of doing things in the normal course of exercising their functions and responsibilities (Hardy and Maguire, 2008). This situation, also called the “paradox of embedded agency” (Garud et al., 2007; Seo and Creed, 2002), describes tensions between individuals and pervasive institutional pressures that shape their roles and associated actions and make it difficult to do things differently.

2.2 Agents in institutions building innovation capabilities

Actors trying to develop innovation capabilities appear to walk a fine line between these two theoretical fields. On one hand, these institutional entrepreneurs must disembed themselves from institutions to be able to innovate and do things in different ways. On the other hand, literature on developing innovation capabilities focuses on the role of “orchestrators”, and strongly suggests that these actors should be well versed in established practices and other embedded actors, especially strategic decision makers, to facilitate uptake and diffusion of new practices thanks to their detailed knowledge of an institution’s inherent complexities. Existing literature does not directly resolve such issues; in this paper, the assumption is made that alternative, complementary roles to an organizational “orchestrators” for building innovation capabilities may exist. Creators of corporate Fab Labs may be one example of a type of alternate profile, but this hypothesis is not explored in detail.

3 METHODOLOGY

Throughout 2015 and 2016, a series of 31 semi-structured and unstructured interviews were conducted with 18 creators and/or managers of corporate Fab Labs, present in 10 multi-national firms. The firms in the sample are large, publically traded companies with over 50,000 employees in the automobile, aviation, banking, consumer electronics, energy, imaging, plastics, and telecommunications sectors. The individuals interviewed were based in three countries: France, Japan, and South Korea. Detailed notes taken during these interviews constitute the primary material used in this study. Additional supporting data used to corroborate or illustrate details from these primary interviews include notes from participative observations in each corporate Fab Lab, PowerPoint presentations and other documentation created by Fab Lab managers, photos, and notes drawn from a series of over 100 secondary interviews conducted with Fab Lab users and non-users.

To identify the extent to which corporate Fab Labs contribute to a firm’s innovation capabilities, these documents were reread in their entirety to identify portions that describe forms of resources, processes, or a prevailing mindset. Examples of resources described include the roles fulfilled by Lab managers, new types of machines present, in addition to annual budgets and personnel. Processes described included the creation of a business incubator, the genesis of the Lab itself, and how ideas take shape as they move from concepts to tangible objects. Finally, mindset is partially described by the presence of rules, charters, codes of conduct, adages, slogans, and other symbols, such as a list of twelve “rules of the garage” intended to promote creativity and invention.

Following a systematic coding for the three broad types of innovation capabilities, individual elements were listed together in each category and placed into subcategories based on either material or ideological similarities. For instance, processes described as a “new business accelerator” and a “corporate idea sprint” were gathered together in a subcategory called “corporate springboards” based

on converging descriptions of giving original ideas an opportunity to thrive. These subcategories, grouped together in terms of overall innovation capabilities, are analyzed in the following section.

4 DESCRIPTIVE ANALYSIS

The theoretical foundation proposed in this paper focuses on individuals who seize opportunities to develop new capabilities for innovation within their firms. Three sets of general questions should be asked to establish whether corporate Fab Labs and their creators fit this description.

1. How do corporate Fab Lab creators perceive and qualify their firm's innovation capabilities, both before and after initiating a corporate Fab Lab project?
2. What resources, processes, and mindsets are generated by Fab Labs? To what extent do these new capabilities build upon pre-existing innovation capabilities?
3. Do Fab Lab managers and creators act with an explicit or declared intent of transforming institutionalized innovation capabilities, and how do they qualify their initiatives?

The first question characterizes initiatives from the perspective of individual actors, exploring *why* they choose exercise agency to become disembedded agents for change. The second pair of questions builds upon the three building blocks of the basic innovation framework proposed, by controlling for pre-existing institutional capabilities inherited by institutional entrepreneurs and the resulting, unique contributions. Finally, the last set of questions aim to establish what institutional entrepreneurs hope to accomplish in developing their projects, and establish whether their actions are in line with, exceed, or fall short of their ambitions. The following sections analyze corporate Fab Labs and their creators in order of these general questions.

4.1 Qualifying firms, their innovation capabilities, and opportunities for change

"Innovation" occupies a more explicit and central role in the formally stated corporate strategies of most firms. All corporate Fab Lab creators interviewed during this study indicated that their firms included innovation as one of the key areas for company development, however in most cases felt that discrepancies existed between strategic ambitions and "reality" within their respective companies. From their point of view, their firm was missing some form of innovation capabilities necessary to realizing the full potential of its strategic goals. According to these actors, tensions stem from two main sources: quickly changing market forces, especially in terms of digital lifestyle and trends, and internal control processes that favor short-term results. Difficulties reacting to changing market forces are commonly identified stumbling blocks for large firms that suggest internal rigidities that favor established capabilities, suggesting the need and opportunity to regenerate innovation capabilities. Management by short-term objectives naturally favors allocating resources to clearly defined projects and expected outcomes. When pushed to the extreme these short-term, ROI-focused allocation processes push aside higher risk, exploratory projects that are not disguised using more acceptable formalisms. One individual described this process as a transformation of "management controls into controlled management."

When asked about existing innovation capabilities within their firms, respondents frequently used qualifiers that point out structural deficiencies using adjectives with strong negative connotations, such as ineffective, inexistent, inefficient, inadequate, and insufficient. Although these terms collectively indicate respondents' critical opinion of existing initiatives, they implicitly acknowledge that *some form* of innovative activities already exists within an organization. Over the course of most interviews, negative qualifiers were tempered or explained with greater precision. One Fab Lab manager pointed out, "It's not so much that [our company is] bad at all types of innovation. In fact, we're probably some of the best in the world at incremental innovation. The problem is that's only part of the equation in innovation. You need new ideas too, and not just ideas, but use cases, proofs of concept, business models, and all the rest."

Even though research subjects tempered their views firm's existing capabilities to innovate, they underscored several opportunities to improve. If a firm innovated effectively and/or sufficiently, the introduction of Fab Labs as an alternative means for building innovation would be redundant, but this was not the case for many respondents.

4.2 Opportunities for developing innovation capabilities through Fab Labs

Creators of corporate Fab Labs described the need to fill various gaps in terms of innovation capabilities, whether in terms of resources, processes, and mindset. The following section identifies unique contributions by corporate Fab Labs in terms of individual capabilities as distinct entities. However, changes in one capability are not exclusive and tend to produce adjustments in another area. For instance, introducing a rapid-prototyping design process based around 3D printers would logically be accompanied by additional resources, such as 3D printers and substrate materials, or a mindset-oriented slogan such as “Make it fly!”. In addition, it is worth noting that research subjects identified opportunities for developing innovation-oriented processes and mindset with nearly equal frequency, with each of these two aspects individually outweighing mentions of opportunities to develop resources. This outlook is briefly developed, independently of the following section in the concluding discussion.

4.2.1 Resources

Resources are the easiest innovation capability to develop in general, and they are the only capability that can be allocated and redistributed within organizations based on identified opportunities. Resource availability in Fab Labs depends greatly on multiple factors, such as an individual actor’s ability to gain support from more embedded actors. When faced with well-positioned actors, Fab Lab creators can position their endeavors both as a means for preparing the firm against the unknown and creating the unknown that could be a competitive strength. This positioning allows them to mobilize resources in a variety of ways, such as using their company’s purchasing and procurement processes, or in one case, receiving the equivalent of a blank check from the company’s CEO.

Lack of institutional resources are not necessarily an impediment to building innovation capabilities either. Six of the ten Labs studied were initially founded through frugal means, with Lab creators resorting to dumpster diving, recovering chairs and small appliances from friends and family members, ordering and self-installing fire-proof carpet from a large e-commerce site, building furniture, rummaging through storage closets, or “borrowing” tools from other divisions. Regardless of the pecuniary resources initially available to each Lab, each of the physical spaces studied is a modest yet pleasant and functional setting.

Human presence is a key resource in Fab Labs, giving a familiar face to what appears to be an institutionally incongruous setting. In all firms studied, at least one of the founders of the Fab Lab is responsible for overseeing its day-to-day operations. All but two Labs have a staff member present during working hours to assist individuals who come in to work on projects. One of these other Labs requires setting an appointment in advance with an individual who comes in from a nearby building. The other two Labs have no full-time staff dedicated to their operation. Rather, an ad-hoc team of nearly 20 individuals collectively run each Lab, every individual contributing a few hours of time each week. Employees in this firm are required to fill out a weekly activity report and assign each half-day work period to an internal billing code. The managers of at least six employees refused to accept unbillable hours, citing reasons such as poorly reflecting team performance, meaning that these individuals could no longer come help in the Lab. One of the co-founders approached the site’s HR director with the problem, who quickly offered to create an unexpected solution: create a fictitious billing code in the system. Employees aware of the code can freely bill working hours, allowing the Fab Lab to seamlessly blend in with more institutionalized practices should some managers so require.

Although corporate Fab Labs only use a fraction of the resources mobilized by their firm’s existing R&D and innovation activities, they tend to inherit rather than produce resources. Almost ironically, even the creators of these projects themselves are inherited resources as employees of the firm. One notable exception is the creation of a “place” where innovation, creativity, open research, discovery, experimentation, prototyping, meet-ups, can be in parallel developed. In this sense, corporate Fab Labs create an innovation resource as a “town square” or “commons”—a centrally located intermediary for innovation, which can be used to agitate and stimulate innovative activities while remaining fully dependent on existing innovation capabilities to pursue developing projects beyond the initial stages presented in the Lab.

4.2.2 Processes

Descriptions of opportunities to develop innovation-oriented processes in Fab Labs are grouped into two main categories: “working with others”, and “doing things differently”. The category working with others describes processes that associate individuals, primarily in ways that break down traditional roles

or barriers. Though similar in description to a cross-functional team, Fab Lab creators distinguish their labs by focusing on individuals as themselves, rather than individuals representing a specific function or job title. In this sense, the Fab Lab becomes a type of internal “fuzzy front end” that—momentarily—blurs out functional roles to the point where an unacquainted observer might easily confuse a mechanical engineer for a community manager or a project accountant for a designer. Working with others also includes opening the door to external actors, such as clients, students, or even employees of a neighboring firm to participate.

The category “doing things differently” describes a fundamental shift from day-to-day activities made possible in Fab Labs, most notably erasing institutional divisions between design and production activities. This process places individuals in an institutionally unfamiliar situation, one that Levi-Strauss (1962) describes as a *bricoleur*, in which they bring their ideas to fruition using whatever tools, materials, and individuals are on-hand in an act of *bricolage*. This does not necessarily imply leaving individuals to their own devices to figure things out themselves. In many Labs for example, informal peer-to-peer training sessions are developed by Lab users to facilitate the process of knowledge sharing and cultivate a sense of community.

Processes inherited from existing innovation capabilities can also be enhanced or enriched by Fab Labs. In one company, an existing, highly formalized process for the creation of new subsidiaries was adapted by the corporate Fab Lab founder to accompany ad-hoc teams from the Lab with an innovative project through the phases of product development, including marketing, legal, and distribution aspects. Based on feedback from initial groups using this “launch” process, the same large firm decided to develop a process for crowdfunding the development of prototypes by using 3rd party online platforms and eventually creating their own online crowdfunding system.

4.2.3 Mindset

Developing an institutionalized mindset receptive towards all types of innovation is a long-term undertaking that takes great efforts, as described in Börjesson et al.’s (2014) longitudinal study of developing innovation capabilities within two automobile makers. A group of three employees from one of the firms included in the aforementioned study decided to create a Fab Lab included in the present research. Despite initial hopes to create highly innovative processes, after a year and a half of operation, one of the Lab’s founders realized that “these structures are far more useful in changing people’s mindset than producing innovations.” Most other Lab managers recognize this opportunity, seeing their mission as one of generating and disseminating a “spirit of innovation” or a “maker mindset” to all reaches of the firm.

Creating a generalized mindset for innovation in the form of a tight-knit community of innovators is the most frequently cited opportunity to create innovation capabilities in large firms identified by creators of Fab Labs. Although the classic nature of a community of individuals might be more appropriately considered a resource in the simple innovation capability framework, it is in the fullest sense a fundamental framework of values by which active Lab participants elect to disembed themselves from their institutional roles to develop innovation capabilities.

The power of an innovation-oriented community mindset can also go beyond resource limitations and unforgiving processes. In one company, a request to create a physical Fab Lab space was refused. One of the engineers responsible for the proposal simply said “No place? No problem!”, adding that physical space can simply take the shape of mental space amongst a large group of colleagues. “Pretending” through a mindset can have similar effects to creating a space as a resource. In this sense, Fab Labs becomes a mental or imaginary square in an alternate dimension, which, like a positive attitude, produces tangible effects while remaining invisible or unimportant to the firm’s more confined institutional forms. The disproportionate size of Fab Labs and the surrounding organizations they intend to serve underscores their symbolic nature in developing an innovation mindset and makes a strong argument for their ability to generate an innovation-oriented mindset. The equivalent of 20 full-time employees and a handful of willing volunteers who help from time to time were responsible for operating Fab Labs available to over 55,000 employees that work on the 10 corporate campuses with Fab Labs included in this study. This assessment does not indicate that these initiatives are unsuccessful, but rather indicate their potency in representing a mindset more favorable to breakthrough innovation rather than a means of creating new processes or supplemental resources. Fab Labs may provide credence for restoring key practices that may have been put aside as institutionalized processes increased in efficiency, such as using tools to make an object oneself, expressing one’s ideas, trying things out, or breaking free from a

day-to-day routine. Once these ideals are re-institutionalized, Fab Labs may no longer be necessary as an embodiment of these values.

4.3 Meaning to change

After identifying opportunities and ways that innovation capabilities are developed by corporate Fab Labs, this final analysis verifies whether Lab creators *intend* to change institutional innovation capabilities, and whether they feel they're able to gain sufficient traction to bring about the intended changes. Of the 18 individuals interviewed during this study, all but four explicitly expressed their intent to change aspects of their company's ability to innovate. Three of the four remaining individuals suggested that their main objective was to change culture or create a place for creativity—elements used by other Lab creators as change agents—worked directly with a colleague who expressed intent for change. The remaining case comes from a project manager tasked with creating a Fab Lab, who recognized the situation as uncharted waters for him and for his regional division. He stated, “we want to make expression of individual creativity a priority to innovate and discover new applications, but do not know how to do this.” This seemingly genuine and honest response reflects the potential existence of both individual and institutional blind spots. If unresolved, these unknowns generate friction or tension between institutional entrepreneurs and institutions.

The primary source of resistance cited by Fab Lab creators stems from uncertainty related to institutional management controls. Reliably gauging intent and effectiveness in ways that control functions can interpret are difficult measurements to establish. Members of Fab Lab communities often suggest what they call “poor proxies” to justify something—anything—in a language already understood by corporate control processes, which are ironically the same source of frustration and incomprehension cited by Fab Lab creators in the introduction to this study. Recurring examples include the number of patents stemming from projects undertaken in Fab Labs, calculating costs and time saved by making in-house prototypes instead of using 3rd party suppliers and onerous procurement procedures, or the number of hours of free peer-to-peer training dispensed in Labs to teach coworkers new skills.

These poor measures may indicate the difficulties of escaping the pull of institutional embeddedness, or constitute a justified first step that disguises Fab Labs as something they're not as a means of ensuring early survival... a form of organizational Trojan horse. Notwithstanding, they partially or substantially occult the core ambitions and intent of institutional entrepreneurs wanting to build innovation capabilities. Later empirical research could examine to what extent this institutional mimicry enables or curtails these types of projects.

5 CONCLUSION & FUTURE RESEARCH

This paper introduces corporate Fab Labs, a new research object in the field of innovation management, along with three key contributions. First, an initial theoretical foundation is proposed for corporate Fab Labs, building upon established innovation literature and a basic framework for innovation capabilities, paired with the notion of institutional entrepreneurs as agents of change. Modest contributions are made to these fields of literature by highlighting tensions between existing roles of actors for building innovation capabilities, namely the role of “orchestrator”, and the requirement of disembeddedness for innovation by institutional entrepreneurs, which could be resolved by identifying complementary roles for building capabilities. Second, an empirical analysis of ten corporate Fab Labs establishes their emergence, from actors identifying initial opportunities to the development of new capabilities for innovation within firms. Interestingly, opportunities to develop innovation-oriented resources was the least mentioned opportunity for capability building identified by practitioners. One explanation could be that these individuals work in a relatively resource-rich embedded environment, and simply take resource availability for granted. An alternative might include a resilient new model for innovation that automatically adapts to available resources while maintaining core objectives, or a resource-independent model for innovation. Finally, this paper suggests several avenues for future contributions, including the impact of transitioning from temporary resources to more permanent ones, the necessity of corporate Fab Labs once an innovation-oriented mindset is established, or how Fab Labs could formalize a process that places individuals directly in a *bricolage* state-of-mind.

In addition to these questions closely aligned with the present paper, additional contributions are welcomed as corporate Fab Labs mature. Related research in this field could look at general traits of firms in which Fab Labs have appeared, such as whether these firms take higher risks overall, whether

the Fab Lab model is less pertinent in smaller businesses, or the types of externalities associated with firms housing corporate Fab Labs.

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— Résumé de thèse —

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Articles en annexe

Cette thèse est une thèse sur essai ; les trois articles suivants figurent en annexe.

Article 1: Fuller, M. & David, A. (2016). *“Resetting innovation capabilities: the emergence of corporate Fab Labs.”* 23rd International Product Development Management Conference, June 2016, Glasgow, Scotland.

Article 2: Fuller, M. & David, A. (2017). *“Making nothing or something: corporate Fab Labs seen through their objects as they cross organizational boundaries.”* 24th International Product Development Management Conference, June 2017, Reykjavík, Iceland.

Article 3: Fuller, M. (2017): *“Fitting squares into round holes: Enabling innovation, creativity, and entrepreneurship through corporate Fab Labs”*. In: Proceedings of the 21st International Conference on Engineering Design (ICED17), Vol. 2: Design Processes | Design Organisation and Management, Vancouver, Canada, 21.-25.08.2017.

Chapitre 1 : Introduction

L'innovation est un enjeu stratégique qui se trouve au cœur de la plupart des entreprises ; ces dernières cherchent à augmenter leurs capacités d'innovation sans cesse. Ayant cet objectif à l'esprit, plusieurs grands groupes ont établi un Fab Lab dans leurs locaux, inspirés par le modèle de Fab Labs établi par le *Massachusetts Institute of Technology* (MIT) (Gershenfeld, 2005).

Ces lieux proposent un accès facilité à de nombreux outils de conception et de fabrication numérique, tels que des imprimantes 3D, des découpeuses laser, ainsi qu'une large communauté de créateurs. Dans le contexte d'une entreprise, les Fab Labs proposent d'influer sur les capacités d'innovations de l'organisation de manière directe et indirecte. La contribution directe s'appuie sur la possibilité de créer des objets innovants à l'aide d'outils proposés dans un lab, tandis que la contribution indirecte est caractérisée par la cultivation d'un état d'esprit innovant et créatif qui sera mis à contribution dans d'autres parties de l'organisation. Ces deux avenues pour générer des capacités d'innovation sont non-exclusives et peuvent être complémentaires.

L'émergence de ces lieux d'innovation dans les grands groupes—un phénomène qui remonte au début des années 2010 et a pris de l'ampleur quelques années plus tard—pose de nombreuses questions de caractère managériale. Notre travail propose d'y répondre au travers d'une interprétation théorique qui s'articule autour de trois questions de recherche. Ces questions ont pour but d'identifier la valeur potentiellement obtenue par une entreprise disposant d'un Fab Lab, ainsi que des éléments pour mesurer et démontrer cette valeur.

Notre première question est ancrée sur les capacités d'innovation présentes dans les organisations. À partir de prismes théoriques établis (Börjesson & Elmquist, 2012; Christensen, 1997), nous décrivons comment un Fab Lab d'entreprise génère et renouvelle (Leonard-Barton, 1992) les capacités d'innovation d'une organisation.

RQ1: Quels sont les effets des Fab Labs sur les capacités d'innovation de l'entreprise?

Notre deuxième question de recherche identifie la valeur dérivée de la production matérielle des Fab Labs d'entreprise. Cette question considère que ces objets peuvent être traceurs de parcours—ou non parcours—des objets qui sont le reflet de leur milieu (Simondon, 2012).

RQ2 : Quels types d'objets y sont créés ? Que reflètent ces objets ?

Enfin, les Fab Labs d'entreprise prétendent permettre aux salariés de faire les choses différemment, de sortir ("*disembed*", Leca et al., 2008) des processus et routines établis. Cette démarche s'apparente à une forme d'entrepreneuriat institutionnel (DiMaggio, 1988 ; Hardy & Maguire, 2008), qui est représentée dans notre troisième question de recherche :

RQ 3: Qui est impliqué dans la création du Fab Lab ?

Comment ces individus interagissent-ils avec l'organisation ?

Structure de la thèse

Le document en anglais présente notre travail portant sur les Fab Labs d'entreprise en trois sections ; ce résumé reprend la même structure pour en faciliter la lecture.

La première partie, composée des chapitres 2, 3, et 4, introduit notre objet de recherche, notre cadre théorique, ainsi que notre approche méthodologique pour étudier les Fab Labs d'entreprise. La deuxième partie, composée du chapitre 5 ainsi que des articles en annexe, présente les résultats principaux de nos recherches. La troisième partie, composée des chapitres 6, 7, 8 et 9, met en discussion ces résultats pour approfondir notre analyse. Cette partie constitue la partie la plus significative de cette recherche.

Notre conclusion résume les implications théoriques, méthodologiques et managériales de notre travail.

Chapitre 2 : Que sont les Fab Labs ?

Afin de mieux comprendre l'émergence des Fab Labs dans le milieu des entreprises, ce chapitre décrit les origines du concept dans un laboratoire de recherche américain, qui s'est transformé ensuite en initiative sociale. Nous traçons leur émergence dans le milieu des entreprises et identifions également des initiatives antérieures qui ressemblent aux Fab Labs.

Les origines du Fab Lab peuvent être tracées au MIT Media Lab—un laboratoire rattaché au Massachusetts Institute of Technology (MIT). Quelques membres du laboratoire avaient déployé un programme de recherche aux interstices des mondes physiques et digitales, cherchant à créer des représentations matérielles de modèles numériques. À la fin des années 1990, Neil Gershenfeld—le chercheur principal dirigeant cette initiative—avait obtenu plusieurs millions de dollars de financement de l'État américain pour poursuivre ce programme de recherche (Gershenfeld, 2015).

Au moment de l'obtention du financement, la législature américaine venait d'appliquer une nouvelle obligation à tout projet de recherche scientifique : le projet devait désormais démontrer l'impact sociétale de la recherche. Étant l'un des premiers à devoir répondre à cette obligation, Gershenfeld ne savait pas comment s'y prendre concrètement. Avec son équipe, ils ont conçu une expérience sociale qui créerait le même environnement que leur laboratoire de recherche à petite échelle, y compris avec toutes les machines de fabrication. En 2001, le *South End Technology Center* à Boston a accueilli l'expérience de Gershenfeld, doté d'un parc matériel coûtant une centaine de milliers d'euros ainsi qu'une équipe de bénévoles qui avaient pour but de former les jeunes de la cité. L'initiative était baptisée le « Fab Lab. »

Peu après la création du premier Fab Lab, des collègues académiques en Norvège, au Costa Rica, et en Inde ont observé l'impact de l'initiative. Ils ont demandé s'ils pouvaient créer leur propre Fab Lab. Gershenfeld et son équipe ont accepté volontiers de partager leur savoir faire, et la collaboration a donné naissance au réseau émergent de Fab Labs.

Depuis la création du premier Lab en 2001, une centaine de lieux dans le monde se sont déclarés « Fab Labs » en 2009. Afin de soutenir ces initiatives, la Fab Foundation a été établie en 2009 pour soutenir le développement du réseau mondial des labs de manière indépendante. Au moment de la diffusion de ce manuscrit, il existe 1680 structures indépendantes qui se déclarent comme « Fab Labs », dont plus de la moitié se trouve en Europe (Fab City Research Lab, 2019).

Étant donné qu'il suffit de se déclarer comme Fab Lab pour en être un, nous avons observé une grande hétérogénéité dans ces lieux, très largement reflétée dans les recherches existantes dans ce domaine. Cela nous indique qu'il existe une certaine ambiguïté autour du concept de Fab Labs, qui engendre des interprétations multiples. Cette notion d'ambiguïté sera centrale dans notre analyse. Cet aspect déclaratif introduit aussi une deuxième limite : il se peut que des initiatives similaires ne se soient pas déclarées comme Fab Labs mais qui pourraient être utiles comme élément de contraste dans notre analyse. Nous avons identifié quelques initiatives au cours de notre recherche, tels que les Centres de Loisirs Utiles créés par une entreprise minière en Alsace, ainsi que les laboratoires de recherche de Thomas Edison.

Bien que les Fab Labs ont été portés par une forte croissance entre 2009 et 2016, il existe peu d'initiatives nouvelles. Cela interroge sur les questions de saturation de marché ainsi que la pérennité du modèle ; nous en tenons compte dans notre analyse.

Chapitre 3 : Cadre théorique

Du fait que les Fab Labs représentaient un objet de recherche émergent au début de nos travaux—surtout dans le contexte d’une entreprise—le cadre théorique à employer était incertain. Ce chapitre résume le prisme théorique que nous avons adopté au démarrage de nos travaux. Il décrit le contexte théorique sous-jacent de cette thèse, sans en être exhaustif. Les éléments présentés dans cette section sont complétés et articulés en fonction des analyses comprises dans nos articles de recherche ainsi que des chapitres présentant nos résultats et analyses.

Cadre initial

Nous rappelons que notre recherche entend identifier et comprendre les contributions faites par les Fab Labs dans un contexte d’entreprise. Pour ce faire, il nous fallait un cadre théorique qui offrait une vision claire des résultats attendus des labs. Par cela, nous entendons les arguments qui ont motivé et justifié la création de ce dispositif, notamment la contribution de capacités à innover.

Un champs de recherche très riche décrit le rôle des capacités organisationnelles (Eisenhardt & Martin, 2000; Teece, Pisano, & Shuen, 1997), avec des éléments pour décrire la façon dont elles peuvent être développées, maintenues et renouvelées (Leonard-Barton, 1992).

Cette perspective a été adaptée au contexte de l’innovation et du champ de recherche des capacités d’innovation. La notion de capacités d’innovation est interprétée de manière hétérogène dans la littérature scientifique. Certains la distinguent comme une forme d’énergie habilitante qui favorise la création de nouvelles offres commerciales (Assink,

2006). D'autres adoptent ce prisme avec l'argument que ces capacités sont l'élément vital d'une organisation (Helfat et al., 2009), favorisant les initiatives inédites (Hamel, 2003) et la création de nouveaux systèmes et processus pour faire face à un environnement de plus en plus concurrentiel (Utterback, 1994). D'autres adoptent une perspective plus systémique (O'Connor, 2008), qui stipule que la valeur de l'innovation n'est pas la somme des éléments individuels mais plutôt le résultat de la production d'un ensemble.

À partir de ces perspectives multiples de capacités d'innovation, quelques chercheurs ont établi des grilles de lecture pour identifier les composants fondamentaux de ces capacités (Börjesson & Elmquist, 2011 ; Christensen, 1997). Cette grille, composée des ressources, des processus, et de l'état d'esprit sera fondamentale dans notre analyse.

Bien que les ingrédients de base des capacités d'innovation contenus dans cette grille sont présents, cela n'indique pas la capacité de l'organisation à les absorber et à les valoriser. Nous considérons que la production matérielle des lieux dédiés à la fabrication devrait servir comme indicateur de la mobilisation de ces capacités (Mahmoud-Jouini, Midler, Cruz, & Gaudron, 2014). Pour tracer le parcours des objets, nous adoptons le prisme théorique des objets frontières (Star, 1989 ; Carlile, 2002 ; Carlile, 2004).

Résumé des notions théoriques clés

Ces travaux mobilisent les notions de capacités d'innovation et d'objets frontières comme éléments théoriques centraux. Des revues de littérature pour chacune de ces notions figurent dans les articles 1 et 2. Notre analyse approfondie mobilise d'autres notions complémentaires, notamment les *management ideas* ainsi que l'entrepreneuriat institutionnel. Le tableau suivant résume la manière dont chacune de ces notions sera mobilisée dans nos travaux :

Tableau 3–1. Notions théoriques clés

Notion théorique	Références clés	Développé et mobilisé dans
<i>Capacités d'innovation ; capacités dynamiques</i>	<ul style="list-style-type: none">- Teece, Shuen, & Pisano, 1997- Lawson & Samson, 2011- O'Connor, 2008- Börjesson & Elmquist, 2011- Christensen, 1997	Article 1; Chapitres 6 & 7
<i>Objets frontières</i>	<ul style="list-style-type: none">- Simondon, 1958- Star, 1989- Carlile, 1998; 2002; 2004	Article 2; Chapitre 8
<i>Management ideas</i>	<ul style="list-style-type: none">- Kramer, 1975- Abrahamson, 1996- Birkinshaw, Hamel, & Mol, 2008- Rauth, 2015	Chapitres 6 & 7
<i>L'entrepreneuriat institutionnel</i>	<ul style="list-style-type: none">- DiMaggio, 1998- Garud, Hardy, & Maguire, 2007- Hardy & Maguire, 2008- Battilana, Leca, & Boxenbaum, 2009	Article 3

Chapitre 4 : Méthodologie

Notre méthodologie a été articulée autour une démarche de recherche collaborative. Cette partie rappelle les origines de nos recherches et décrit comment nous sommes parvenus à travailler avec de nombreux lieux. Elle résume les types de données récoltées dans une vingtaine d'entreprises aussi bien que d'autres lieux semblables qui se trouvent dans plusieurs pays.

Bien que notre objet de recherche principal se trouve dans le milieu des entreprises, nous avons fait un effort pour explorer d'autres types de Fab Labs et « makerspaces » (Lallement, 2015). L'objectif de cette démarche complémentaire était de mieux comprendre les points communs et différences entre ces lieux. Bien que la comparaison entre des lieux « ouverts » au grand public et ceux qui sont « fermés » dans les entreprises soit tentante, nous avons délibérément fait le choix de mettre ces réflexions de côté pour nous concentrer sur les implications managériales associées aux Fab Labs d'entreprises.

Nos interactions sur le terrain ont donné naissance à un corpus composé de comptes rendus détaillés de nos entretiens, ainsi que d'une collection de photos, vidéos et croquis des lieux. À cela, nous y avons rajouté la documentation produite par les labs d'entreprise, tels que des présentations, documents, procédures. Enfin, nous avons tracé la production matérielle de ces lieux : les objets.

Les deux tableaux suivants (Tableaux 4-1 ; 4-2) résument les lieux étudiés. Le dernier tableau (Tableau 4-3) détaille les matériels récoltés par notre étude.

Tableau 4–1. Fab Labs d’entreprises étudiés

Secteur	Entreprise (Maison mère)	Effectif	Nom du lab	Année de création
	Air Liquide	> 40 000	iLab	2012
Transports	Air France Industries	> 14 000	MRO Lab	2017
Aéronautique	Airbus	> 70 000	Protospace	2014
Électronique	Alcatel-Lucent (Nokia)	> 50 000	Le Garage	2013
Énergie	Areva NP (Orano)	> 40 000	L@B Areva	2009
Technologie	Autodesk	> 7 000	Pier 9	2013
Bancaire	Cardif (BNP Paribas)	> 9 000	Cardif'Lab	2014
Technologie	Dassault Systems	> 10 000	3DS Lab	2013
Énergie	EDF	> 150 000	I2R	2012
Technologie	Evosoft (Siemens)	> 500	Fab Lab Nuremburg (partnership)	2012
Énergie	GRDF (Engie)	> 10 000	« Fab Lab »	2015
Électroménager	Groupe SEB	> 20 000	SEBLab	2013
Énergie	GRTgaz (Engie)	> 3 000	Lab	2016
Commerce	Leroy Merlin (Adéo)	> 85 000	BricoLab	2013
Automobile	Nissan	> 140 000	—	<i>proposé</i>
Télécom	Orange	> 150 000	Thinging Orange Lab	2012 (inactif)
Télécom	Orange	> 150 000	Le 3e Lieu	2016
Énergie	Pacific Gas & Electric (PG&E)	> 23 000	IoTlab	2016
Automobile	Renault	> 125 000	Renault Creative Lab	2012
Électronique	Ricoh	> 110 000	Tsukuroom	2015
Industriel	Saint Gobain	> 180 000	StartLab	2015
Transports	SNCF	> 150 000	Les 574	2015
Aéronautique	Snecma (Safran)	> 15 000	Atelier Innovations Services	2013
Électronique	Sony	> 85 000	Sony Creative Lounge	2014

Tableau 4–2. D’autres Fab Labs et makerspaces étudiés

Nom du lab	Lieu
American Center Korea	Seoul, Corée du Sud
Artilect	Toulouse, France
Ateliers Leroy Merlin	Ivry-sur-Seine, France
Carrefour Numérique	Paris, France
Centre de Loisirs Utiles	Bollwiller, France
DeVinci Fablab	Courbevoie, France
DMM.make	Tokyo, Japon
Electrolab	Nanterre, France
Fab Lab Provence	Marseille, France
Fab Lab Seoul	Seoul, Corée du Sud
Fab Research	Yokohama, Japon
FabCafe	Tokyo, Japon
Fablab Descartes	Noisy-le-Grand, France
FabLab Digiscope	Gif-sur-Yvette, France
Fablab Kamakura	Kamakura, Japon
FabLab Kannai	Yokohama, Japon
FabLab Setagaya	Tokyo, Japon
FabLab Shibuya	Tokyo, Japon
FabLab Tsukuba	Tsukuba, Japon
FacLab	Gennevilliers, France
Galvanize	San Francisco, États-Unis
ICIMONTREUIL	Montreuil, France
Idea Factory	Gwacheon, Corée du Sud
La Casemate	Grenoble, France
La Fabrique Numérique de Gonesse	Gonesse, France
La Paillasse	Paris, France
Laboratoire d'Aix-périmentation et de Bidouille	Aix-en-Provence, France
Le Petit FabLab de Paris	Paris, France
Makers'Base	Tokyo, Japon
Proto204	Bures-sur-Yvette, France
RocketSpace	San Francisco, États-Unis
SQYLAB	Saint-Quentin-en-Yvelines, France
Station F	Paris, France
Usine.io	Paris, France
Volumes	Paris, France
WoMa	Paris, France
YOUFACTORY	Lyon, France

Tableau 4–3. Récapitulatif des données récoltées

Documents	
Présentations destinées à la direction	16
Autres présentations	36
Vidéos en ligne	19
Articles de presse	48
Entretiens	
Entretiens semi-directives	121
Entretiens non-directifs et conversations	116
Participation	
Nombre d'activités organisées ou animées	8
Nombre d'activités en qualité de participant	12
Observations	
Journées d'observation	85
Photos d'objets, lieux et individus	2897

Chapitre 5 : Résumé des articles

Ce chapitre présente un résumé des trois articles en annexe.

Article 1 : “*Resetting innovation capabilities*” (2016)

Étant donné les interprétations diverses des capacités d’innovation, ce premier article traite notre question de recherche initiale (RQ1) pour identifier comment les Fab Labs contribuent aux capacités d’innovation d’une entreprise.

Pour ce faire, nous avons exploité soixante-neuf entretiens de recherche effectués avec les salariés et dirigeants de dix-huit entreprises différentes. Nous avons employé une grille d’analyse simple des capacités d’innovation (Börjesson & Elmquist, 2011; Christensen, 1997) qui identifie les ressources, processus, et l’état d’esprit généré par les Fab Labs.

Article 2 : “*Making something or nothing*” (2017)

Les Fab Labs disposent d’outils pour « fabriquer (presque) n’importe quoi » (Gershenfeld, 2015) ; ces moyens de production donnent naissance à des objets visés par notre deuxième question de recherche (RQ2). Notre analyse emploie le cadre théorique des objets frontières (Carlile, 2002; Carlile, 2004) qui permet de tracer le parcours des objets créés dans les Fab Labs au travers des frontières organisationnelles.

Cet article s’appuie sur une collection de plus de 500 photos prises dans quatre Fab Labs d’entreprise différents. Les objets identifiés par cette analyse reflètent un certain progrès, passant d’objets très simple à des créations relativement sophistiquées. Cette forme d’analyse permet d’évaluer la maturité des lieux.

Article 3 : “*Fitting squares into round holes*” (2017)

Le troisième article regarde l'action des créateurs des Fab Labs d'entreprise sous le prisme de l'entrepreneuriat institutionnel (Dimaggio, 1988) avec notre troisième question de recherche (RQ3). Par cet article, nous avons tracé la démarche des individus qui ont créé un Fab Lab.

Chapitre 6 : le Fab Lab comme idée managériale

Notre étude initiale des capacités d'innovation a révélé que l'ensemble de ressources, processus et l'état d'esprit créé par le Fab Lab ne sont pas forcément nouveaux dans l'organisation : on fait du neuf à partir du vieux. Pour comprendre cette dynamique, nous avons souhaité comprendre le raisonnement managérial qui a poussé à la création d'un Fab Lab. Afin de déterminer ce que les créateurs de lab avaient à l'esprit, nous nous référons à leurs déclarations individuelles d'attentes pour ces lieux. Nous faisons une distinction entre objectifs et résultats attendus ci-après (Tableau 6-1).

Tableau 6-1. Déclarations d'objectifs d'un Fab Lab

Objectifs (Niveau 1)	Résultats attendus (Niveau 2)	Stratégies (activités/méthodes) (Niveau 3)
Augmenter les capacités d'innovation	Croissance des activités	Créer des opportunités de croissance
		Soutenir des start-ups
		Développer de nouvelles activités
	Transformation organisationnelle	Fournir des ressources nécessaires pour effectuer un changement
		Créer l'unité dans les équipes
		Faciliter l'apprentissage
		Stimuler un réseau d'innovateurs
		Augmenter l'agilité
		Soutenir des équipes projets innovants
		Élargir un écosystème d'innovation
	Activités annexes	Soutenir la créativité
		Créer des prototypes
		Générer des concepts disruptifs
		Tester des idées rapidement
		Passer d'une idée à l'action
		Rendre des idées tangibles

Bien que l'ensemble des lieux aient pour objectif d'augmenter les capacités d'innovation de l'entreprise, nous observons une dichotomie dans les résultats attendus. D'une part la croissance de l'entreprise et d'autre part la transformation organisationnelle. Le Fab Lab est donc « embauché » (Christensen, Hall, Dillon & Duncan, 2016) comme solution pour obtenir ces résultats. Cette dynamique s'apparente à une notion de management ou *management idea* (Birkinshaw, Hamel, & Mol, 2008).

À ce stade, notre analyse et notre intuition nous invitent à déterminer si l'on pourrait considérer les Fab Labs d'entreprise comme une *management idea*. Cette dernière représente « un ensemble de connaissances de ce qu'un dirigeant devrait faire » dans une situation donnée (Kramer, 1975, cité dans Birkinshaw et al., 2008). Les *management ideas* sont composées d'éléments de deux dimensions clés : la rhétorique et la technologie (Birkinshaw et al., 2008 ; Rauth, 2015). La première dimension décrit pourquoi et à quels moments une *management idea* devrait être adoptée, tandis que la deuxième détaille quoi et comment celle-ci peut être appliquée. Enfin, pour faciliter la diffusion d'une *management idea*, il lui faut une certaine forme d'« interprétabilité » (Benders & Van Veen, 2001) qui permet de l'adapter à de nombreux contextes managériaux.

Avec ce prisme théorique, nous menons une analyse détaillée de nos données empiriques pour identifier s'il existe des éléments rhétoriques et technologiques interprétables associées aux Fab Labs d'entreprise. Cette analyse porte sur l'utilisation d'un « label », la proposition de valeur principale, des « menaces » et justifications externes, ainsi que des principes, pratiques et techniques. Hormis quelques interrogations de fond sur la proposition de valeur—détaillées dans les chapitres suivants—nous avons démontré que l'on peut considérer que les Fab Labs sont l'incarnation d'une *management idea*.

Chapitre 7 : Reformulation de la promesse centrale des Fab Labs d'entreprise

Dans le chapitre précédent, nous avons qualifié les Fab Labs d'entreprise comme une *management idea* et sa représentation théorique (Birkinshaw et al., 2008) au travers sa construction rhétorique et technique. Cependant, nous avons identifié un écueil : la crédibilité de la proposition de valeur des Fab Labs. Dans ce chapitre, nous proposons une reformulation de cette proposition de valeur. Pour ce faire, nous partons des différences identifiées entre les activités principales de l'entreprise par rapport à celles des labs.

Nous identifions quatre différences majeures dans l'activité des Fab Labs d'entreprise : l'élimination ou modification des divisions de travail classiques, le floutage des notions institutionnelles d'expertise, l'effacement de nombreux effets d'une bureaucratie, ainsi que l'accompagnement de l'expression individuelle. Les quatre comportements observés sont généralisables à l'ensemble de lieux observés.

Après plusieurs mois de réflexion sur ces différences observées et la formulation d'une proposition de valeur, nous avons été amenés à l'hypothèse suivante : est-ce que l'environnement isolé des Fab Labs facilitent un changement d'état organisationnel ?

Nous considérons que les conditions générées par un Fab Lab offrent un antidote des effets des grandes structures. Dans un lab, le fonctionnement de l'entreprise est réduit à un état naissant et embryonnaire. Dans ce lieu, l'innovation peut émerger d'un environnement opérationnel simple et sans encombre. Nous baptisons cette action et fonction un « reset » ou *remise à l'état*.

L'analyse proposée dans ce chapitre explore la définition formelle du terme *reset* ainsi que ses propriétés. Nous nous appuyons sur cette définition technique pour proposer une grille théorique de l'opération du *reset*. Ensuite, nous cherchons à valider si les Fab Labs peuvent réellement prétendre à effectuer un *reset* des capacités d'innovation. Enfin, nous déterminons s'il serait avantageux d'employer la notion de *reset* comme proposition de valeur centrale.

Chapitre 8 : L'évaluation de l'efficacité d'un Lab à effectuer une *“innovation reset”*

Dès le départ de nos recherches, la majorité des praticiens avec qui nous nous sommes entretenus ont indiqué qu'ils avaient besoin d'identifier un indicateur de performance adéquat pour qualifier la performance du Fab Lab. De ce fait, nous souhaitons apporter une analyse complémentaire à partir de la proposition de valeur formulée dans le chapitre précédent : le « reset ».

Dans l'article 2, nous avons introduit la notion d'objets frontières (Carlile, 2002, 2004 ; Star, 1989) qui sert à identifier la capacité de l'organisation à s'approprier les objets fabriqués dans un lab et à les transformer par un processus d'innovation plus élaboré.

Dans le chapitre précédent, nous avons déterminé que les Fab Labs effectuent un reset du type « fondamental » qui est caractérisé par la création de nouveaux objets à partir d'éléments existants. Les artefacts étudiés suggèrent que les objets réalisés dans un lab sont de nature différente par rapport au reste de l'organisation pour deux raisons. Dans la plupart des cas, cette différence s'explique par le fait que les créateurs d'objets ont adopté des rôles souvent bien différents que leur poste habituel. Dans quelques cas, l'objet réalisé est tout à fait unique pour l'organisation. Dans les deux cas de figure, nous avons pu déterminer que le Fab Lab était un dispositif nécessaire pour effectuer ces changements.

L'existence de ces objets inédits nous invite à évaluer si ces derniers ont eu une influence sur les capacités d'innovation de l'organisation. Pour ce faire, nous avons étudié la trajectoire des objets dans les organisations ; seul un lab étudié avait développé un dispositif qui affichait une porosité systémique entre le lab et l'organisation.

Chapitre 9 : L'observation des « *resets* » en action

Le chapitre précédant analyse les objets résultants d'un *reset* ; cette lecture suppose que l'environnement des Labs n'altère pas le processus de conception et de création d'un objet. Nous nous appuyons sur nos observations pour voir si cette hypothèse est réaliste.

Nous rappelons d'abord les processus de conception classiques pratiqués dans l'ensemble des entreprises que nous avons rencontrées lors de nos recherches. Au démarrage d'un projet, le périmètre du projet ainsi que ses objectifs étaient formalisés de manière explicite, ce qui permet de former une équipe de projet. Ces étapes initiales constituent une forme de cohésion qui précède l'activité de conception. Ce modèle de cohésion est souvent considéré comme un prérequis de la conception (Dubois, 2015). Pour notre analyse, nous avons voulu déterminer si ces étapes initiales et formatives étaient préservées dans l'environnement du lab.

Les activités présentes dans les Fab Labs démontraient que la conception pouvait précéder la cohésion, d'une manière tout à fait ordinaire. Ce résultat préliminaire peut être enrichi par trois perspectives complémentaires dans des recherches ultérieures.

D'abord, il nous semble essentiel de mener des expériences où le modèle typique de cohésion avant conception est introduit dans cet environnement. Est-ce que cette formalité limiterait les contributions des uns et des autres ? Est-ce que cette dynamique pourrait freiner l'évolution de l'identité de l'objet à concevoir ? D'autre part,, nous sommes convaincus que d'autres disciplines pourraient offrir une lecture riche des dynamiques observées. Enfin, il nous semble essentiel d'adopter une posture critique à notre hypothèse : peut-être l'environnement du lab est une forme de cohésion suffisante pour faciliter les activités de conception.

Chapitre 10 : Conclusions et implications managériales

L'objet de cette thèse était d'investiguer les Fab Labs d'entreprise et en proposer une interprétation théorique. Au début de cette recherche, ces lieux venaient de naître dans de nombreuses organisations. Nos recherches, présentées dans ce manuscrit ainsi que dans les trois articles de recherche, avaient pour objectif de 1) augmenter notre compréhension de la façon dont ces espaces influencent les capacités d'innovation d'une organisation, 2) contribuer à une « théorisation » (Birkinshaw et al., 2008) des Fab Labs comme une *management idea*, ainsi que 3) élaborer des implications managériales de ces espaces.

Conclusion

Au départ de cette recherche, nous avons mené une analyse qui a identifié les éléments de base que l'on retrouve dans les Fab Labs pour promouvoir les capacités d'innovation. Cette analyse nous a permis d'identifier que les labs n'offrent que peu de ressources nouvelles à une entreprise à caractère industriel. Cela nous a poussé à découvrir l'intention managériale sous-jacente, qui a été développée dans le chapitre 6 du manuscrit. Cette analyse a démontré que dans l'ensemble des cas, l'initiative de la création du lab avait pour but d'augmenter les capacités d'innovation d'une entreprise. En observant ce raisonnement, nous avons formulé l'hypothèse que les Fab Labs pourraient être une *management idea*. Ces idées du management représentent une stratégie généralement acceptée pour répondre à un enjeu rencontré dans de nombreuses situations, moyennant la possibilité de les « interpréter »—ou adapter—à une situation donnée.

Nous avons déterminé que la notion de Fab Labs se prête à une interprétation facile selon deux dimensions : celle de la rhétorique ainsi que celle de la technologie. Cependant, notre analyse a révélé que la proposition de valeur des labs était trop ambiguë. Ce manque de clarté peut entraîner des attentes irréalistes qui peuvent nuire à la pérennité de ce type d'initiative et contribuer à un comportement de mode managériale.

Contributions théoriques et recherches futures

Partant de notre qualification de Fab Labs comme une *management idea*, nous avons proposé un modèle théorique pour illustrer comment ce lieu crée des opportunités pour innover. Nous avons appelé cette dynamique un « reset », explorant les sens multiples de ce terme qui vont bien au-delà d'une simple remise à zéro.

En complément de ce modèle théorique, nous proposons un outil pour évaluer l'impact et l'efficacité d'une action de « reset ». Ce dispositif concerne la production tangible et matérielle de ces espaces en observant leur parcours au travers de frontières organisationnelles.

En parallèle de ces contributions théoriques, nous avons observé une dynamique sociale atypique pour des activités de conception dans les Fab Labs. Cette observation invite des recherches ultérieures.

Implications managériales

La qualification des Fab Labs comme une *management idea* comporte plusieurs implications pour les dirigeants d'entreprise. Par dirigeant nous entendons les cadres—chefs d'une équipe—aussi bien que les individus cherchant à promouvoir des changements dans l'organisation quel que soit leur position ou grade hiérarchique.

Tout d'abord, notre qualification de Fab Lab comme une idée de management reconnaît de manière implicite qu'il s'agit d'une solution qui cherche à répondre à une problématique organisationnelle. La réussite semble être conditionnée à une forme d'ajustement mutuel : le lab doit s'adapter à l'organisation, mais encore plus critique est la capacité de l'organisation de s'adapter aux dynamiques du lab.

Ensuite, nous avons décrit la possibilité de faire un « reset » ou reconsidération des mécanismes d'innovation d'une entreprise. Avant d'actionner ce levier, nous suggérons que les managers cherchent à comprendre son fonctionnement, les résultats que cela peut procurer, ainsi que les risques associés.

Enfin, bien qu'il soit raisonnable de s'attendre à ce qu'un Fab Lab produise quelque chose de différent par rapport aux routines organisationnelles, cela ne garantit pas un résultat innovant. Les labs peuvent être une ressource utile pour innover, mais cela ne dispense pas l'organisation de son obligation de fournir une vision stratégique et le cadrage nécessaire ; en bref, du management.

RÉSUMÉ

Inspirés par un modèle établi par une initiative sociale du Massachusetts Institute of Technology (MIT) en 2001, des salariés de plusieurs grandes groupes ont établi des Fab Labs d'entreprise avec l'intention de transformer les capacités d'innovation de leur entreprise.

Cette thèse examine l'univers des Fab Labs entreprise, s'appuyant sur des données empiriques récoltées dans des dizaines de labs, avec des activités de recherche principales ayant lieu entre 2014 et 2017 dans les laboratoires de quatre grands groupes mondiaux. L'objectif de cette recherche est de 1) identifier si les Fab Labs d'entreprise influencent les capacités d'innovation d'une organisation, 2) articuler et affiner la représentation managériale utilisée pour justifier la création d'un tel lieu, ainsi que 3) esquisser un mécanisme simple qui permet aux décideurs stratégiques d'évaluer si les activités dans un lab lui permet d'atteindre ses objectifs.

MOTS CLÉS

Fab Labs d'entreprise, capacités d'innovation, idées du management

ABSTRACT

Based on a pattern established by an MIT academic outreach program created in 2001, individuals in dozens of large organizations established corporate Fab Labs in recent years with the intent to transform their firm's ability to innovate.

This thesis investigates the world of corporate Fab Labs, building on empirical data gathered from dozens of labs, with core research activities taking place in the labs of four large multinational firms from 2014 through 2017. The purpose of this research is to 1) identify whether corporate Fab Labs influence an organization's innovation capabilities, 2) articulate and refine the managerial representation used to support the creation of these labs, and 3) outline a simple mechanism for managers to evaluate whether a lab attains its desired outcomes.

KEYWORDS

Corporate Fab Labs, innovation capabilities, management ideas