User Innovation in Digital Environment

Clemence Cheruy

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User Innovation in Digital Environment

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Madame Isabelle BOURDON Maître de Conférences HDR, Université de Montpellier	Directrice de thèse
Monsieur Nassim BELBALY Full Professeur HDR, Montpellier Business School	Directeur de thèse
Monsieur Dwight MERUNKA Professeur, IAE Aix Marseille	Rapporteur
Monsieur Christophe ELIE-DIT-COSAQUE Professeur, Université Paris Dauphine	Rapporteur
Madame Laura A COSTANZO Full Professeur, Southampton Business School	Examinatrice
Monsieur Régis MEISSONIER Professeur, IAE Montpellier	Président

Montpellier Research in Management, Place Eugène Bataillon – CC 19001 – bâtiment 19, 34095 Montpellier Cedex 5

L'innovation utilisateurs dans un environnement digital

Résumé :

Le développement des technologies de l'information permet aux entreprises et aux consommateurs de travailler ensemble pour développer des innovations. Les entreprises s'appuient sur ce mouvement de co-création en ligne à travers des plateformes de génération d'idées. Les mécanismes sous-jacents des interactions utilisateurs/entreprises deviennent un sujet majeur au niveau théorique et pratique. Ce travail doctoral vise à mieux comprendre les déterminants des innovations co-créées par des consommateurs. Dans un premier article, nous étudions les acteurs qui contribuent aux innovations externes, et principalement les *lead-users* dans un contexte de *crowdsourcing* afin de proposer une typologie de ces consommateurs spécifiques. Deuxièmement, nous explorons en profondeur la notion de performance de l'outil et identifions que ces outils, tels que les plateformes d'idéation et les logiciels open source, doivent regrouper certaines conditions pour augmenter la capacité innovante des entreprises. Enfin, nous nous concentrons sur l'ensemble du processus de création d'innovations et proposons un modèle théorique basé sur les théories de la résolution de problèmes et les *need-solution pairs.* Les résultats obtenus dans ce travail doctoral permettent de contribuer à la littérature traitant du *crowdsourcing* et de l'innovation utilisateurs mais également de répondre à des questions managériales sur la recherche virtuelle d'innovations. Le recours à ces trois niveaux d'analyse (acteurs, outils et méthodes) est essentiel aux entreprises pour intégrer une vision globale de l'environnement extérieur et le succès d'une stratégie d'innovation ouverte. Les trois articles de ce travail permettent d'aider les entreprises à augmenter leur niveau de co-création avec des *lead-users*. Cette recherche offre également une meilleure compréhension de la conception des outils technologiques pour maximiser l'échange et la création d'idées innovantes par les consommateurs. Le modèle théorique proposé permet d'optimiser la recherche de solutions innovantes par le biais d'un processus adapté de formulation du problème.

Mots clés : co-création, innovation utilisateurs, systèmes d'information, formulation de problème

User innovation in digital environnement

Abstract:

Advance in information technology allows companies and customers working together to develop innovations. Firms widely rely on this online co-creation movement through idea generation toolkits and the underlying mechanisms of user-firms interactions become a challenging topic to investigate for both theory and practice. Across three articles, we aim to better understand user innovations determinants. In the first article proposition, we build on lead user literature to investigate the actors contributing to external innovations. Second, we explore the notion of tool performance as mean to facilitate innovation. We identify that online tools, such as ideation platform and Open Source Software need to aggregate several conditions leading to promote innovative outputs. Finally, we focus on the overall process allowing firms to entirely externalize the idea generation process and methods to improve this process. We propose a theoretical model built on problem-solving and need solution pairs theories. Overall, the findings extend both user innovation and crowdsourcing literature and provide practical implications for virtual search for innovations. The investigations of three level of analysis: actors, tools and methods is critical. The three articles of our thesis could help firms to increase interactions with expert users. This research could also provide better understanding on how to design ideation toolkits to maximize innovative context. Finally, our theoretical model might help firms to optimize the search for innovative solutions *via* an adapted process for problem formulation.

Keywords: co-creation, user innovations, information systems, problem formulation

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M Bifé.

Une profonde pensée à mon grand-père, mon ange gardien…

List of Articles

N°	Title	Authors	Journal	Status	Conferences Presentation
1	Identifying Lead User Online: a Study of a Co-creation Platform	**Belbaly,** Nassim **Cheruy,** Clémence	Research Policy	Submitted September 2016	EGOS 2014 AIM 2014
2	OSS popularity: understanding the relationship between user-developer interaction, market potential and development stage	**Belbaly,** Nassim **Cheruy,** Clémence **Robert,** Frank	Systèmes d'Information et Management	3rd Round in September 2016	AOM 2015 AIM 2016
3	Formulate or not Formulate: Solving Problem with a Dynamic Capabilities Perspectives	**Cheruy**, Clémence **Belbaly,** Nassim **von Krogh,** Georg **Küçükkeles**, Burcu	Academy of Management Review	*This paper was totally reviewed during a research visiting at ETH Zurich with Prof. von Krogh from may 2016 to August 2016. Submission December 2016*	OUI 2015

Introduction

Fifteen years ago, who would have imagined that a multinational brand could entrust a lambda citizen with a product conception that would grasp worldwide attention? This dream came true in 2008 for Carlos Arturo Torres, a young Colombian student, who was selected to present "the car for the Megalopolis of the future" in Shanghai International Automobile Industry Exhibition. Actually, Carlos Torres won a design contest initiated by Peugeot in 2008, in which contributors were asked to imagine and design the *car of tomorrow*[1]. This young Colombian was selected from more than 2500 idea propositions, and received attractive rewards including 10,000 euros and participation to Auto Shanghai 2008. In addition, Peugeot committed to produce Carlos Torres's concept in limited edition for collectors.

Through these kind of initiatives, a brand can take into account consumers aspirations and requirements, and at the same time, allowing them to participate in product conception.
While numerous brands are using these web-based initiatives today to ask Internet users to participate in logo creation, product conception or service improvement, this phenomenon has become common practice not only for brands or product industry, but also in a more extended and diversified way. This kind of initiative appeared many years before, in other forms such as what is called 'participative sponsorship', whereby people voluntarily give money to a specific cause. A good example is the French monument restoration whereby several French heritage monuments, such as the "Panthéon", which was completely renovated thanks to individual donations.

Through these examples we can understand the need for organizations to rely on external sources to attempt a specific objective, which could be financial or simply just to find potential ideas.

This phenomenon could be explained through two main reasons. Firstly, the current environment, including globalization and information technology growth, which leads firms to rely much more on innovation as the main driver of economic performance (OCDE 2008). Here innovation becomes one of the most important sources of growth and value creation for

[1] http://www.peugeotdesignlab.com/fr

organizations. As a result, the need for innovation is embedded in the very core of the products, services and operations for many organizations (Yoo et al. 2012).

Secondly, while innovation becomes one of the main concerns for organizations, advances in technology and the growing of the Internet pushes firms to use and develop new techniques and sources to create innovative outputs. The extensive adoptions of innovations with digital technologies radically change the nature of products and services, leading organizations to totally redefine ways to create innovation. Specifically, the aforementioned examples illustrate the need to open boarders and to look outside of traditional business frameworks and also to use the digital environment to harness these new sources of innovation. As a result, understanding innovation is one of the most important issues to gain sustainable competitive advantages. As a result companies are now adopting open approaches by opening borders, sharing internal knowledge, practices and integrating external actors in decision-making processes (Chesbrough 2006). Thus the open innovation paradigm represents a salient opportunity for firms to develop commercially attractive new products and services and also poses new questions that have emerged from a practical, as well as, theoretical perspective. This new paradigm is the foundation of our research.

1. Research Objectives

Scholars have commonly acknowledged that the use of digital environment have "democratized" the innovation process, redefining the control over innovation activities across multiple systems (Chesbrough et al. 2006). As a result, the locus of innovation is overcoming the periphery of firms, changing the way of harnessing creativity, new product development and innovative ideas. Consequently, firms draw on novel forms of organizing activities (Yoo et al. 2012).

Firstly, the evolution of company behavior comes from the increased awareness that the best way to lock in consumers and respond to their evolving needs is to involve them in the development of firm's new products or services (von Hippel 2005). Consumers are also increasingly more open to take part in new product development experiences today as shown by international study trends which support that 6.1% of the UK population, 5.2% of the US population and 3.7% of the Japanese population were involved in innovation activities serving their own needs for new or modified consumer products (von Hippel et al. 2012; Ogawa &

Pongtanalert 2013). As a result, while this co-creation movement and practices are continuously growing, it attracts academics' interest in order to understand and explain the role of external users in firms innovative activities (e.g. Bogers et al. 2010).

Second, the two examples previously cited clearly revealed that firms also use digital environment emergence as a mean to interact with external sources, all over the world. Indeed, this co-creation movement is accentuated by the emergence of new technologies that facilitate interactions with users or consumers. One approach to use information technology that is receiving substantial attention is "crowdsourcing", neologism created to define the act of outsourcing a task performed by an employee to a large group of people external to the company in the form of an open call (Howe 2006). Understanding the key factors that drive the generation of ideas that an organization wants to implement is thus necessary to fully appreciate the potential of these crowdsourcing communities (Bayus 2013).
Therefore, there is a need for firms to implement new forms of innovation activities stemming from the open innovation paradigm. In opening borders, companies can open themselves up to harness creativity and improve new product development (NPD) innovativeness. This co-creation movement is represented by 1) including external users in NPD processes and 2) the use of crowdsourcing techniques to interact with external partners.
As a result, the **user innovation** in digital environment enabled by **crowdsourcing** techniques constitute our two main research objectives, with the aim to increase our understanding of mechanisms and functions that allow for this co-creation movement.

2. General Problematic

In order to produce innovative products, firms need to follow an innovation strategy including several steps (Tidd et al. 2005), from idea gathering to product implementation:

1. **Search for opportunities** – how and where firms can find new ideas?
2. **Select** – what and why firms are going to choose one project?
3. **Implement** – How firms are going to make it happen?
4. **Capture** – How firms can benefit from implementing of a new product?

As previously discussed, the innovation process goes through a non-linear process, whereby firms can diversify and share ideas, knowledge and resources in order to generate additional

value. In other words, the amount of innovation potential that can be poured into the innovation funnel increases because more parties are actively involved, as shown in figure 1.

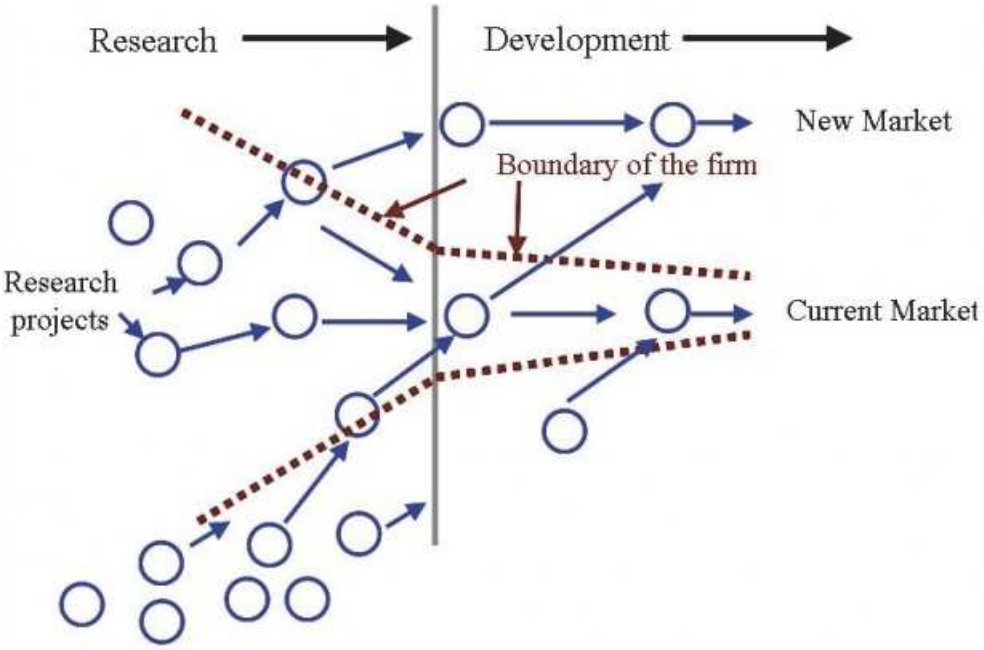


Figure 1: Open Innovation Model (Chesbrough 2003)

As suggested by Chesbrough (2003), new opportunities or ideas are currently coming from external sources. Thus, in order to investigate the overall mechanisms allowing firms to develop innovations from external sources, our research will focus on the early stage of the innovation funnel, the search for new opportunities.

User innovation literature suggests that integrating customers, or users, into the early stages of an innovation process could potentially increase the likelihood to harness creativity (Bogers et al. 2010). First, ideas emerging from users have huge probability to reflect their needs and wishes (Prügl & Schreier 2006) which increases the chances to develop attractive products. Second, by explicitly expressing their needs, users provide what is called "solution information" which represents important customer-based suggestions describing how ideas can be transferred into marketable products (von Hippel 1994).

As a result, a better understanding of user's innovative nature can increase the chances to understand why users might be ready to engage in the innovation process. While companies need to increase knowledge on how to detect external innovators, scholars commonly recognize that it appears difficult to identify specific innovative profiles in the mass of users available in the market (Piezunka & Dahlander 2015). In addition, innovation management

literature points out that even if companies are able to detect the right innovator, they still have to struggle on how to work with, how to integrate external actors within the firms and how to re-establish innovation processes and management support (Piller & Walcher 2006; Block et al. 2016). Our research is thus positioned around these questions and aims to add contributions by answering the following issue: **What are the determinants of user innovation?** The term "determinants" will refer to three specific research questions:

- **RQ 1:** Who are external **actors** who enhance innovative ideas?
- **RQ 2:** What are the best **tools** to gather these ideas?
- **RQ 3:** Which are the best **methods** to collect innovative inputs?

We approach these questions by working on a cumulative dissertation, and each paper will address one of these research questions. Nevertheless, rather than presenting a simple summary of our papers, we would like to emphasize the link between these three levels of analysis and their impacts on 1) the emergence of creative behavior and 2) the optimization of innovation process (Figure 2). Thus, each paper presented in this dissertation contributes to explore one of the three levels. We have organized the papers following a logical reasoning across three axes to answer the specific research questions (Figure 2).

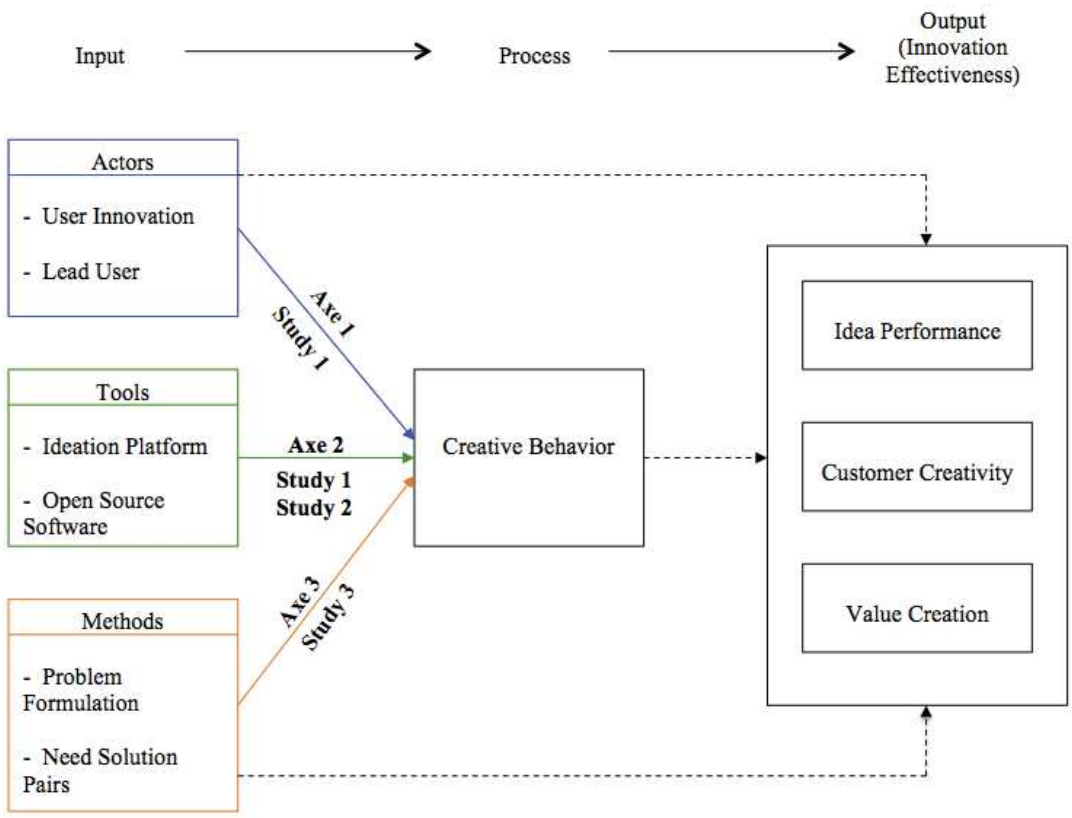


Figure 2: Conceptual Research Model

Creativity is a central topic in organizational and innovation studies because it allows firms to create value and generates an appropriate framework for new product development (Amabile et al. 1996). In addition, creativity can also provides useful solutions for problem solving (Shalley et al. 2004) and insights into future problems in rapidly changing environments. As a result, scholars have attempted to explain processes whereby organizations could harness creativity (e.g. Moreau & Dahl 2005; Toubia 2006; Simonton 2011; Zhou & Oldham 2001). At the individual level, creativity is defined as an "individual's ability to produce or respond in a way that is novel and appropriate, useful, correct, or valuable to the task at hand" (Amabile 1983). However, in the work environment, creativity often depends on social interactions and relationships (Kim et al. 2016; Sonenshein 2014; Amabile et al. 2005). Taking into account that organizations are much more rely on external sources to foster creativity, there is a need to understand how external sources can lead to the emergence of creative behavior (Anderson et al. 2014). The research objective of this doctoral dissertation is to investigate the inputs (actors, tools and methods) that lead to the generation of novel and useful ideas.

3. Conceptual Framework

Each of the three axes is related to a specific research question that we have previously defined in identifying research challenges from existing literature related to each level:

- **Axe 1** - Actors as a source of innovation
- **Axe 2** - Tools as a mean to co-create
- **Axe 3** – Methods to optimize the innovation process

Axe 1 - explores external actors and their specific role and characteristics as a source of innovation. As previously mentioned, our approach is built on user innovation literature with the aim to deeper investigate the nature and profile of these actors. Specifically, this axe investigates the link between external users and the emergence of creative behavior leading to potential innovative ideas. We thus aim to understand and explore how organizations can detect creative users who will be efficient in the creation of innovative ideas. To do so, we specifically focus on one category of users. Previous research has demonstrated that one category of consumers labeled as **lead users** are recognized to be particularly relevant to

generate innovative ideas. Lead user are defined as expert users who present strong product knowledge, and who are ahead of trend in terms of expected benefits and use experience related to the product (von Hippel 1986). The focus on lead users comes from many reasons; the first is that researchers have found that 82% of Lead Users developed their own version of industrial products that they have studied, against only 1% for common users (Urban & von Hippel 1988). Second, they found that Lead Users products are more commercially attractive and generate ideas which have much higher interest compared to mass consumer ideas (Urban & von hippel 1988; Morisson et al. 2000). Lead users products also showed better sales potential than traditional developed concepts (Lilien et al. 2002). However, methods to detect lead users still present some limitations, especially when relying on crowdsourcing techniques (Spann et al. 2009). Thus, we would like to deepen our understanding on the lead user profile and precisely in an online context in order to provide answers for ***RQ1- Who are the external actors who enhance innovative ideas?*** In this respect, article 1 investigates the nature of online lead user profile by exploring its characteristics in this specific context.

Article 1 (qualitative research) – is entitled "Identifying Lead User Online: a Study of a Co-creation Platform". Earlier versions have been presented at Association Information et Management (*AIM*) conference (2014) and European Group for Organizational Studies (*EGOS*) conference (2014). The paper has, since September 2016, followed review process in Research Policy.

This study contributes to analyze the online profile of lead users by investigating the following question: *how to detect lead user on ideation platform?* To answer this question we built on previous literature on lead user characteristics, applied in an open ideation context. We subsequently followed a specific research protocol by first screening all participants to identify potential lead users and then conducted in-depth interviews to validate the characteristics of online lead users to confirm their lead user status. Our results show some variations concerning the three main characteristics compared to existing literature, allowing us to define an online typology of lead user profile.

Axe 2 - investigates tools as mean to co-create. Relying on Internet Toolkits, companies can ask users to design concepts for new products and collect innovative ideas via Internet-based idea competitions (Piller & Walcher 2006; von Hippel & Katz 2002). While axe 1 underlies the role of the actors, we aim to better understand how firms can co-create with external users. Through crowdsourcing processes, users tend to generate ideas that score significantly higher

in terms of novelty and customer benefit than traditional new product development methods (Poetz & Schreier 2012). As crowdsourcing has been acknowledged to constitute a promising method to gather user ideas (e.g. Afuah & Tucci 2012), we build on this stream of literature to investigate the role of IT tools to leverage innovations. Specifically, we study two aspects of these crowdsourcing techniques, across two different tools: **Open Source Software** (OSS) and **ideation platform**. First, we focus on idea competition to understand why many information technology based ideas competitions fail to meet requirements upon which active participation and thus production of creative outputs is established (Leimeister et al. 2009). In other words, we aim to understand what the conditions of idea competition toolkits are that lead to the emergence of creative behavior. Second, requester-participant relationship in ideation context and crowdsourcing literature is aware of possible comparison with the user-developer relationship in open source software (Fitzgerald 2006; Hetmank 2014). In order to better understand how this new model of production can lead to create and enhance creativity, we propose to extend our study to the field of OSS, by focusing on user-developer interactions and the link with the generation of innovative ideas. As the interrelations between tools, actors and creative behavior is still under explored, we propose to deeper study this link through the following research question ***RQ 2- What are the best tools to gather these ideas?*** In this respect, article 1 investigates ideation platform as tool to enhance innovation and article 2 explores factors that lead to OSS performance, creating a valuable support for idea generation.

Article 1 - as previously explained, this paper aims to explore lead user profiles in an online context. Hence, this study also provides a relevant field to answer the question related to axe 2 by exploring how this toolkit can help users/participants to generate innovative ideas. The research context of this paper is designed around an ideation platform that we previously developed to reach professional objectives. Following recommendations from past research in crowdsourcing, we initiated an ideation challenge, asking participants to "invent the next tablet generation". We also aggregate specific conditions in order to enhance participants' interactions (votes, comments…). Observations of participants' behavior and in-depth interviews allow us to demonstrate that interactions among participants as well as challenge-related motivations represent relevant conditions for the generations of creative ideas.

Article 2 (quantitative research) - is entitled "OSS popularity: understanding the relationship between user-developer interaction, market potential and development stage".

Earlier versions have been presented at Association Information et Management (*AIM*) conference (2016) and Academy of Management (*AOM*) conference (2015). The paper is currently, since September 2016, in 3rd round of reviewing process in Systèmes d'Information et Management.

Literature review studied in Axe 2 allowed us identifying several challenges related to OSS performance and the need to understand the nature of user-developer interactions as drivers of innovations (Wagstrom 2005; von Krogh & von Hippel 2006). Therefore this paper analyzes data from 657 OSS projects in the SourceForge database in order to investigate the following question: *does the combined effect of user-developer interaction and market potential lead to greater OSS popularity?* Our results show that information flow reflects the amount and nature of developer-user interactions and mainly explains OSS popularity. In other words, this OSS tool represents a relevant platform to enhance creative behavior and attract additional users.

Axe 3 – aims to study the process linked to optimize the innovation process. As we previously focused on who are the innovative actors and how to interact with them, we here propose to deeper investigate the overall process allowing not only gathering innovative ideas, but also the optimal one. When firms decide to outsource the search for innovation, they often expect to find solutions to specific problems (Franke et al. 2014; Thomke & Fujimoto 2000). We thus suggest to firstly focus on problem solving stream of literature to understand this process. Hence, we explored problem-solving process and examined the different steps and related challenges. Academics suggest that firms are often confront problem formulation difficulties, in transmitting inaccurate or incomplete information to problem solvers (e.g. Maheswaran & Meyers-levy 1990; Cowan 1990; Sitkin & Weingart 1995, Tyre & von Hippel 1997). As a result, when firms decide to crowdsource solutions, the first step is to manage the transformation from internal problem identification to clear formulation for external solvers. Recently, the "need solution pairs" theory suggests that it is possible to solve problems without passing trough the formulation step (von Hippel & von Krogh 2016). However, due to its novelty, this theory still lacks empirical, as well, as a theoretical background. Furthermore, past research highlighted that while crowdsourcing represents a pertinent technique to solve problems, it remains difficult for firms to capture values from external solutions (Bloodgood 2013). In other words, even if firms collect innovative solutions, the process enabling firms to gain competitive differentiation through innovations is still under

explored (Peppard et al. 2011). In order to extend knowledge on how firms can really benefit from finding external solutions and optimize external problem-solving process (Prahalad & Ramaswamy 2004b), we propose to deeper explore the methods of outsourcing a problem through the following research question: ***RQ 3: Which are the best methods to collect innovative inputs?*** In this regard, article 3 intends to conceptually explain why and when firms have to formulate, or not, a problem to optimize the search for solutions, and then how this process can lead to capture value from these solutions.

Article 3 (conceptual research) – is entitled "Formulate or not formulate: solving problems with a dynamic capabilities perspective". Earlier versions have been presented at the Annual Open and User Innovation (OUI) conference (2015). This study aims to answer challenges identified in axe 3 namely the optimization methods and value capture process during external problem-solving process. We put forward this paper to build a theoretical framework to answer the following research question: *How and why organizations have to formulate the problem, or not?* Our reasoning is built on a crowdsourcing context and we explore this question by drawing on the evolutionary theory perspective applied to both problem formulation and need solution pairs. We explained complementarity between these two processes by relying on the evolutionary theory (Staw 1990) of ideas to optimize the search of solutions. After a deep analysis of existing literature, we came up with the conclusion that we have to consider the idea as the unit of analysis. Then, we coupled the analysis of literature with observations on an experimental ideation challenge and argued that optimization of solutions might come from the idea progression process among participants during idea generation phase (Mainemelis 2010). Furthermore, in order to explain the process of value capture in our specific context, we based our reasoning on Teece's (2007) view of dynamic capabilities (DC) and propose that idea elaboration process has to be couple with a DCs approach in order to optimize the search of optimal solution in problem-solving process.
At the end, we propose a conceptual model explaining (1) the iterative process between PF and NSP and (2) the specific conditions by which a firm might formulate or not a problem in order to optimize and capture value from potential solutions.

4. Main Contributions

Our research is positioned at the crossing of Innovation and Information Systems literatures. By studying three levels of analysis, namely actors tools and methods, we add our

contribution to extend knowledge for each theory mobilized in these fields. First, we offer new insights to the lead user theory by extending past research from an offline to an online context in order to provide a first typology of online lead user construct. Second, we reinforce knowledge on Open Source Software performance theories, by exploring the nature of user-developers interactions and their impact on OSS popularity. Finally, we contribute to better understand the overall problem-solving process studied in an external context, by proposing a conceptual model explaining how firms can optimize and capture benefits from crowdsourcing a problem. These contributions will be further discussed in the general discussion section, at the end of this document.

5. Organization of Doctoral Research

As explained, each axe developed in this doctoral dissertation respectively focus on actors, tools and methods as determinants of user innovation. Thus, we firstly began by reviewing existing literature related to 1) user innovation and lead users theories, 2) crowdsourcing literature with a specific focus on ideation platform and open source software and 3) problem-solving and need solution pairs theories. This literature review allowed us defining challenges that we will aim to contribute.

Second, we defined relevant fields of study in order to empirically answer the identified challenges. As a result, article 1, 3, 4 and 5 are related to the same field of study: the development of our own ideation platform. We developed The Minder Platform in an experimental context following a professional project for Montpellier Business School. We used this opportunity to create a research field suitable to advance our idea of studying online lead users detection (axe 1, Article 1) as well as the tool itself as a mean to co-create (axe 2, Article 1). In addition to specifically studying lead users, we also investigated this field of study to explore creative behavior of common users, and motivational factors related to ideation context (article 4 and 5). However, we did not include these two papers (A4; A5) in our dissertation, as these papers were only presented in conferences and are not yet fully developed. Still, we will discuss these papers in the general discussion section as it represents avenues for our future research, and will present the works in progress in appendix.

In order to investigate the OSS tool as mean to innovate, we collected data from SourgeForge database and explored the relation between user-developers interactions and OSS popularity (Article 2). Finally, by combining empirical observation on The Minder Platform and analysis of literature in problem-solving and need solutions pairs theories, we develop a conceptual

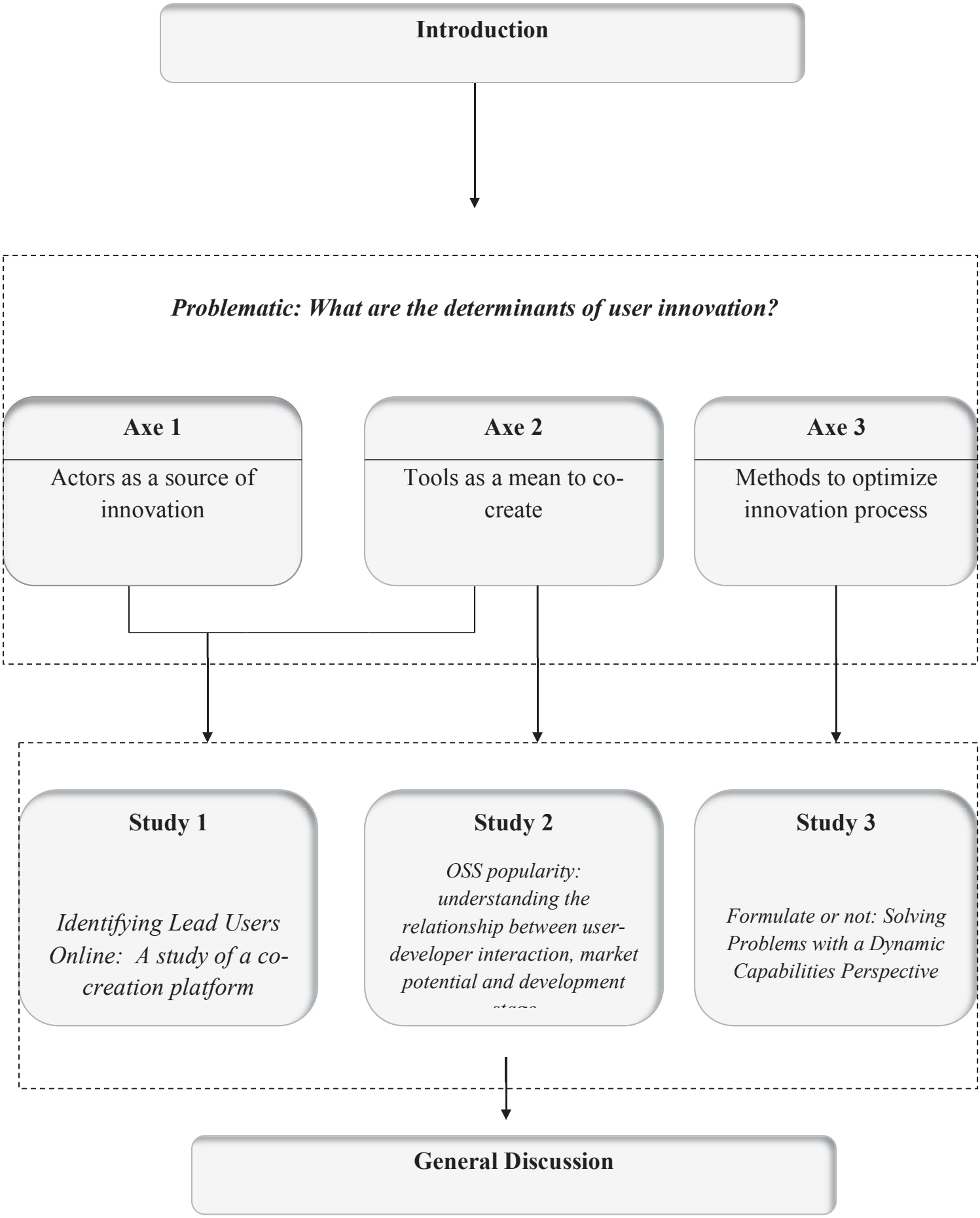
model to explore the methods allowing to optimize the search for innovative ideas (axe 3, article 3). A summary of these different steps is presented in Table 1.

Work perspectives			2013-2014				2014-2015				2015-2016			
Literature review Axe1 - Axe 2 – Axe 3														
Problematic Definition														
Data collection														
Quantitative	Screening and questionnaire ideation platform													
	Data on SourgeForge													
Qualitative	Interview potential lead users													
Papers Development for Journals and Conferences	A1	AIM/EGOS Research Policy												
	A2	AOM/AIM SIM												
	A3	OUI												
	A4	PDMA												
	A5	AIM												
Research Visiting ETH Zurich with Prof. von Krogh (3 months)														
Dissertation finalization														
Preparing and giving courses - Innovation Management (Montpellier Business School)														

Table 1: Planning of doctoral work

6. Structure of the Dissertation

Our dissertation is organized in four main sections. The first three sections present axe 1, 2 and 3. For each axe, we first present the research interest explaining motivations and objectives for this specific field. Second, we define concepts and present literature related to this axe. Third, we identified research challenges from this literature in order to explain the need for deeper investigations. Finally, we present the respective study and explain how we answer these challenges. Full papers are presented in the appendices. The fourth section is dedicated to a general discussion, explaining main contributions for each axe, as well as theoretical and managerial implications, limits and avenues for future research.


Introduction
Problematic: What are the determinants of user innovation?
Axe 1
Actors as a source of innovation
Axe 2
Tools as a mean to co-create
Axe 3
Methods to optimize innovation process
Study 1
Identifying Lead Users Online: A study of a co-creation platform
Study 2
OSS popularity: understanding the relationship between user-developer interaction, market potential and development
Study 3
Formulate or not: Solving Problems with a Dynamic Capabilities Perspective
General Discussion

Axe 1 – Actors as a Source of Innovation

In this part, we will first present research interest of studying the actors as source of innovation. Second, we will address theoretical background related to user and lead user innovation. Third, we will discuss research challenges highlighting needs for further investigations. Then, we will suggest answers to these challenges through the presentation of study 1.

1. Research Interest

Traditionally, the introduction of new products in the market place is a result of professional designers who are responsible for designing products for consumers. The customer participation was limited to customers' surveys, interviews or other marketing tools to collect simple information or feedbacks (Griffin & Hauser, 1993). More recently, several industries have developed many new products that were not developed by designers working at firms but rather by the users themselves (Schreier et al., 2012; von Hippel, 2005). For a long time, companies have understood that user and consumers' needs are important to take into account. However, it is now evolving towards a new phenomenon in which consumers are recognized as active partners (Prahalad & Ramaswamy 2004a). In addition to take consumers' opinion into account, companies tend to outsource the process of new product development. Concrete examples of innovative products designed and invented by consumers are numerous. Highly regarded business firms more and more rely on consumers to gather new ideas and create innovation, such as Starbucks, Adidas, Dell or IBM and potentially obtain novel ideas at relatively low costs (Huang et al. 2014). Another successful example is the case of Threadless. The web-based t-shirt company uses an online competition platform in order to crowdsource the design process of their shirts. In less than one year, the company reached a profit margin of 35 percent and was on track to reach $18 million in 2006 with fewer than twenty employees (Howe, 2008). This type of example shows the importance and benefit to focus on users as a powerful source of innovation. As a result, the co-creation movement has become increasingly attractive to firms to gather innovation. Co-creation is defined as the creation of value by individuals or consumer communities who produce marketable value which benefits economically for the firm (Zwass 2010).

To better understand this co-creation movement, scholars developed user innovation theories and commonly argued that users innovate because their needs are not adequately met by existing products available on the market (von Hippel, 1986, 1988). This is to say that when users are not fully satisfied by a product, they tend to try to answer this need themselves, by completing, improving or even inventing new features or new product. This phenomenon is particularly notable in specific sector such as medical equipment, extreme sporting equipment, scientific instrument and IT solutions (Franke et al. 2006; Lilien et al. 2002; Morrison et al. 2000; Morrison et al. 2004; Luthje 2004). This specificity found its origins in entrepreneurial activities in which individuals find their own solutions to satisfy their needs. But at this stage the entrepreneurs did not always realize that the needs they sought to fulfill were broad and businesses could be created in fulfilling them (Bhave, 1994). The user innovations are therefore likely to have a huge impact on the mass market and be better perceived by consumers with a most important commercial impact (Franke et al. 2006). However, and despite the fact that the benefits of user innovation are fully recognized, academics argue that there is a need to better understand the process linking the innovative individuals, the creative behavior and the innovation itself. Indeed, previous research has revealed *"contradictory findings regarding the nature of involved customers, and the channels of communication that enable co-creation"* (Mahr et al. 2014).

As a result, this new phenomenon has lead to the emergence of several questions, with both theoretical and managerial concerns:

- who these co-creators are?
- how to catch the more creative ones?
- how to transform a potential idea into an innovative product to the market place?

The transformation of the overall innovation process raises important practical and theoretical questionings that academics need to answer, in order to better understand the co-creation and user innovation phenomenon.

One of the first answers emerged from research into "sources of innovation" because academics acknowledge the need to "re-understand" the very beginning of where an innovative idea comes from in the innovation process. Von Hippel (1986, 1988) proposes that users who are (1) ahead of an important market trend and (2) expect high benefits from innovating will be most likely to develop attractive innovations. The lead user theory

represents a promising answer to the question of what the difference is between users who come, or do not come, with attractive innovations (Schreier & Prügl 2008). Despite the huge investigations on the lead user theory (e.g. Franke et al., 2014; Franke and Shah, 2003; Magnusson et al., 2014; Urban and Hippel, 1988), recent research noted that even if it allows to better understand innovators' profile, scholars need to deeply focus on the lead users characteristics (e.g. Jensen et al. 2014). Indeed, lead users are considered as rare subjects and additional characteristics might be used as proxy to identify lead users species (Schreier & Prügl 2008). In addition, it seems that the nature of lead user is context-dependent as well. For example, depending of activity sectors, environment or communities' practices, lead users might evolve or differ from their prior characteristics.

Hence, we aim to add our contribution in order to highlight the nature of innovative customers and deeper investigating their creative behavior in different and specific context.

In the next part of this section, we present and define first the concept of user innovation, and second specific concept of lead user. We then identify challenges for research and the positioning of our work.

2. Defining Concepts

2.1.User innovation

For more than 20 years, academics have demonstrated evidence on user innovation, across studies among a wide range of industrial product types where innovating users are individual consumers (von Hippel 2005). The user innovation theory has its origins in strategic management literature. In fact researchers in this field already identified five roles for customers: resource, coproducer, product, buyer and user (e.g. Finch 1999). In other words, customers were already seen as participative, and their contributions are directly related to product usage and to be consistent with usage in prior literature (e.g. Lengnick-Hall 1996; Nambisan 2002). Nambisan (2002) identifies that customers might assume three roles in order to be considered as participative (table 2).

Customer Role	NPD Role	Key Issues/Managerial challenges
Customer as resource	Ideation	• Appropriateness of customer as a source of innovation • Selection of customer innovator • Need for varied customer incentives • Infrastructure for capturing customer knowledge • Differential role of existing (current) and potential (future) customers
Customer as co-creator	Design and development	• Involvement in a wide range of design and development tasks • Nature of the NPD context: industrial/consumer products • Tighter coupling with internal NPD teams • Managing the attendant project uncertainty • Enhancing customers' product/technology knowledge •
Customer as user	• Product testing • Product support	• Time-bound activity • Ensuring customer diversity • Ongoing activity • Infrastructure to support customer-customer interactions

Table 2: Customer roles in NPD (Nambisan 2002)

This table indicates that customers

are take part in activities in each phase of New Product Development (NPD) process. First, 'customer as resource' acts in the first phase of innovation process: idea generation. They represent valuable resources to gather new ideas, new concepts, and can play a fundamental role in the generation of new product ideas.

Second, 'customer as co-creator' can contribute to various activities in the second phase of the innovation process: idea implementation. They may play an active role in product design and development activities. For example, marketing literature explains that during this specific phase, firms ask customers for technical inputs and technical guidance throughout development and testing (e.g. Coviello & Joseph 2012).

Third, 'customer as user' acts in the last phase of the innovation process: idea testing and commercialization. During this step, customers are involved in products testing, and allow firms to detect product flaws early in the development cycle and to minimize costly redesign and rework (Nambisan 2002). In addition, the variety of customers is directly related to a variety of expectations from them, which considerably increase chances for firms to fit mass market expectations when launching a new product. This kind of customer involvement is particularly valuable for firms in trial and error activities and reduces failure rates in market entry and penetration.

Therefore, the user and manufacturer can expect different kinds of relationships and can be extend to specific functions, depending on activity sectors, type of product and phases of the innovation process. User innovation literature is the essence of this relationship understanding and aims to highlight theoretical and practical insights of the users-manufacturers interactions.

In this stream of literature, we consider users as "firms or individual consumers that expect to benefit from *using* a product or service and in contrast, manufacturers expect to benefit from *selling* a product or service" (von Hippel 2005).

For several years, researchers empirically demonstrated that a large part users innovate because they draw on sticky and local knowledge and they expect to benefit from using and possibly selling the innovation and from enjoying the innovation process (Bogers et al. 2010). In other words, users interpret local information and their own knowledge to identify their needs and also to develop solutions to fill their needs. The higher the stickiness is of solution information held by the producer, the more a user-innovator tends to rely on locally available solution knowledge (Luthje et al. 2006). As a result, user innovation literature argues that two types of incentives push users to innovate. First, users directly benefit from using the innovation (Urban & von Hippel 1988) and second, they might be able to profit from selling the innovations to firms, or even as user-entrepreneurs (e.g. Shah & Tripsas 2007).

Having explained the main motivations of users to innovate, innovation literature also investigates the question of who these co-creators are, which is one the prior questions, as mentioned above, in order to help firms to re-define the innovation process. Specifically, regarding the first step of innovation process – *ideation* - firms need to focus on consumers' appropriateness as a source of innovation. In addition, another issue related to the ideation phase is the selection of customer innovator (see. table 2). In other words, firms and scholars both recognized the necessity to better know profile characteristics of the innovative users, which might help to detect and select not only innovative users, but the one who are the most able to produce breakthrough innovations (Luthje & Herstatt 2004).

To answer these issues, research has focused on a particular type of user and consumer – referred to as a lead user – because such lead users have been shown to have the potential to develop truly novel product ideas and concepts (von Hippel 1986), better than ordinary or common users. Von Hippel (1986, 2005) define these specific users as users who face needs that mainstream users will face months or even years later and who expect to benefit significantly from solving these needs early. Research argues that using the lead user is one of the most promising ways to develop breakthrough innovations because lead user innovations tend to have higher performance and market potential than other innovations (e.g. Lutjhe & Herstatt 2004). Therefore lead user theory was originally proposed as a way to selectively identify commercially attractive innovations (von Hippel 1986; 2005), because lead users are

recognized as having the required expertise and knowledge to invent solutions to answer their needs.

As a result, user innovation literature begins to investigate lead user profile, in order to better understand who these specific consumers are.

2.2.Lead user: characteristics and specificities

The initial definition of lead user emerges from von Hippel (1986) and proposes that lead user have two original characteristics. First, the *high expected component* was derived from the fact that these specific customers anticipate high benefits from obtaining a solution to their needs. The notion of dissatisfaction is thus recognized to positively impact likelihood to develop innovations when users identify new needs that are not addressed in the existing market (Herstatt & von Hippel 1992). Second, *the ahead of trend characteristic* is related to the fact that lead user are the vanguard of important market trends and support innovation by solving future problems in the mass market, which leads to high commercial attractiveness of their innovations (Herstatt & von Hippel 1992). However, lead users remain difficult to detect in the mass-market. Thus, academics have explored these lead users in different markets and sectors, in order to propose additional characteristics to better understand these specific consumers. As presented in table 3, scholars investigate a variety of activity sectors and samples that allow them to identify four other characteristics.

Sector	**Type of users samples**	**Main findings**	**Sources**
Printed circuit CAD software	136 attendees at PC-CAD conference	• Lead users demonstrated innovative antecedents compared to non-lead users • Innovations from lead user are better perceived than concepts developed by CAD-systems • Lead user serve as opinion leaders and accelerate the innovation diffusion	Urban & Hippel 1988
Library information systems	Employees in 102 Australian libraries	• Users with lead users characteristics (lead userness component) are more able to develop innovative concepts • Opinion leader is one characteristic of lead userness	Morrison et al. 2000, 2004
Extreme sporting equipment	197 members of	• Users within a community tend to carefully take into	Franke & Shah

Sector	Type of users samples	Main findings	Sources
	extreme sporting clubs	account opinion of users who present lead users profile	2003
Outdoor consumers products	153 recipients of mail order catalogs for outdoor activity	• Product-related knowledge positively impacts the user innovation effectiveness • Lead usersness explains likelihood of user innovation	Luthje 2004
Kite surfing	414 kite surfers from extreme sport communities	• Lead usersess characteristics positively impact innovations attractiveness and foster diffusion to the mass-market • Users with lead user profile demonstrate high use experience and technical abilities	Franke et al. 2006
Various industries such as telecommunication, motor vehicles, software	Sample of 81 lead users selected in the course of 10 lead user projects	• Lead users with a high level of direct use experience make better contributions than do equally qualified individuals without such experience	Hienerth et al. 2007
Extreme sports communities: sailplaning, technical driving and kite surfing	451 members within the 3 extreme sports communities	• Field (domain)-related variables explain an individual's lead userness	Schreier & Prügl 2008

Table 3: Evidence of Lead users innovations & characteristics

As a result, product-related knowledge seems to be essential in finding solutions that improve products. This characteristic of lead users consists of know-how regarding the design of existing products and of the materials used and technologies available on the market, which allows lead users to modify the product, make technical changes to the product or develop new techniques to use the product (Luthje 2004; Morrison et al. 2004). Then, the lead users' product usage experience and technical abilities are related to generating the most innovative ideas (Hienerth et al. 2007), which is supported by Franke et al. (2006) who find that the local resources of users (e.g., their technical expertise) positively influence the attractiveness of innovations. In addition, user involvement is positively associated with innovative and commercially attractive designs and serves as a method of identifying lead users (Luthje 2004). Luthje (2004) shows that lead users are driven by a strong interest in being informed

beforehand and to outdo others, which distinguishes their involvement. Finally, lead users' opinion leadership emphasizes how they are active contributors within the community and how they demonstrate strong leadership (Franke & Shah, 2003; Morrison et al. 2000; Schreier & Prugl 2008). Lead users may also play an important role in the diffusion of many innovations (Morrison et al., 2004). Urban and von Hippel (1988) suggest that lead users might serve as opinion leaders that accelerate new product diffusion with user communities, and even among mass-market.

Six lead user characteristics have been reveled by anterior research, across various field of study and various users community namely *ahead of trend, expected benefit, product knowledge, use experience, involvement and opinion leader*. Scholars offer a consistent theoretical background to better explain the mains characteristics of lead user, who are recognized to be the most able to develop breakthrough innovations (von Hippel et al. 1999).

However, in practice, the detection of these users is often situation specific and not based on user characteristics (von Hippel 1976). As a result, the elaboration of lead user identification methods is still a major challenge in order to help firms to ease the identification process. The next part focuses on lead user detection methods.

2.3.Lead user detection

Originally, one way to identify and integrate lead users for firms is to use the lead user method (e.g. Urban & Hippel 1988; Lilien et al. 2002). This approach follows a problem-solving approach (Simonton 1999) starting from the definition of the problem field to the generation of novel ideas for that specific field. Once the field is selected, internal research teams work on identifying main needs and trends in this field, in interviewing technological experts and mass market-users. This step may allow recognizing a specific trend, and constitutes the right direction for the search of users who are ahead of this market trend i.e. lead users. Several search techniques have been introduced in order to appropriately select users who are at the leading of the identified trend.

2.3.1. Screening

This method consists of screening a population of users for lead user characteristics. The screening approach is based on a survey covering a large user group via written questionnaires or telephone interviews in order to explore whether the respondents show the required lead user characteristics. The high potential of users can subsequently be contacted and interviewed in more detail to deeper explore their profile. Early studies have used

screening methods to detect lead users. For example, Luthje (2000) used screening methods in lead user studies in two areas (game development and public transportation). After contacting more than 2000 persons, based on carefully developed quantitative criteria, he identified 22 lead users for further explorations, which represents only 1,1 percent of sampling efficiency. In other words, this methods appears to be very costly and time consuming, and academics agreed that it is only suitable for small populations restricted to a search within the boundaries of this population (von Hippel et al. 2009).

2.3.2. Pyramiding

The pyramiding search process is based on network approach, as it relies on the assumption that people with a strong interest in a field tend to know people more expert than themselves (Lilien et al. 2002). This search process is a variant of "snowball sampling" which uses the same assumptions in a given network. In other words, the aim of these methods is to ask a known innovative user to recommend suitable peers, i.e. people presenting lead users characteristics. However, pyramiding has been demonstrated to be more efficient than snowballing, as it allows searchers to "move up the pyramid" – to find people with more of a given attribute – rather than staying at the same level (von Hippel et al. 1999; von Hippel et al. 2009). Several studies (e.g. Morrison et al. 2004; von Hippel et al. 2009) empirically compared screening vs. pyramiding, and show that the pyramiding networking process in each case identifies the best solution within the search space, using an average of only 30% of the effort required by mass screening. They also show that the relative efficiency of pyramiding vs. screening increases with a more important population size.

2.3.3. Broadcasting

Lakhani (2006) introduces the idea that to identify lead users, academics and firms might *broadcast the problem*. This method relies on asking a question into an online community with the assumption that it is an efficient way to get in contact with successful problem solvers. This method is based on the fact the innovation often comes from outside established research communities, thus, broadcasted a problem allows to identify external problem-solvers with their own technical domains (Jeppensen & Lakhani 2010). This technique is particularly relevant for open innovation, as it should promote the number and quality of solutions (Piller & Walcher 2006).

3. Challenges for Research

While numerous research successfully apply the lead user methods using, most of the time, a combination of the three methods (e.g. Herstatt & von Hippel 1992; von Hippel et al. 1999), academics acknowledge some important limitations.

First, as explained above, these methods are efficient only in specific communities (expert communities), which limits the chances to increase problem solvers variety, diversity and number. Indeed, it has been argued that future research should apply lead user methods under a range of conditions. For example, Piller & Walcher (2006) used TIC supported self-selection system to detect lead users. But the authors recognized that "the study was limited by the way how the sample was drawn", as participation was limited to customers of specific area in the specific field (Adidas shoes owner in selected retailed outlet). In other words, even if toolkits for idea competition (such as the lead users method) is one method to select lead users, it limits the participation of users who are already involved in a specific community. Yet, past research into problem-solving literature induce that exploring new knowledge to solve problem often lead to find better solutions with a higher degree of novelty (March 1991). Indeed, due to the "functional fixedness" effect, users who are very familiar in using an object, are often blocked from using that object in a novel way, and may be tempted to develop creative ideas (Adamson 1952). This theoretical assumption has been empirically validated in research on innovation (Hienerth et al. 2014). For example, Dahl & Moreau 2002 deeply examined the cognitive process leading to creative thinking and outputs. The authors found that drawing on "far" compared to "near" analogies increase the generation of more novel and creative ideas. More recently, Franke et al. (2014) compared target-market problem solvers versus analogous-market problem solvers and the impact of usefulness and novelty of solutions. The authors showed that although solutions provided by problem solvers from analogous markets show lower potential for immediate use, they demonstrate higher levels of novelty (Franke et al. 2014).

Therefore, while it has been proved that firms need to open boarders in order to increase the chances to find innovative solutions, it appears that the search for external problem-solvers has to be extended to market or sector, different than the initial one, which remains difficult when using the lead user methods.

Second, regarding detection of innovative customers, past research highlighted that mass-screening methods are low sample efficiency, costly and rely only on self-assessment on

respondents (e.g. Spann et al. 2009), which leads to numerous bias. Furthermore, since lead users are 'rare subject' (von Hippel 1986) because of their specific characteristics, they are even more difficult to detect. Indeed, the less frequent lead users in a population are, the lower the sample efficiency is and the higher the search costs are (Belz & Baumbach 2010).

In addition, although the literature on lead users established the importance of lead users characteristics to detect them, empirical studies are often limited to an *offline context*. As described above, lead user detection occurs within specific groups of users, and among well-established communities. Yet, the advances in technology and the growing of the Internet should offer numerous other possibilities to widen the number of external innovative users. The underlying idea is to outsource idea generation phase to a potentially large and unknown population (Poetz & Schreier 2012). This online unknown population has been fully documented in innovation and information systems literature and referred to the "crowd"; and the initiative to gather potential ideas from the crowd has consequently become known as "crowdsourcing"(Agerfalk & Fitzgerald 2008; Howe 2006). However, little is known on how to identify rare subjects via crowdsourcing techniques, and is this specific context relevant to catch innovative ideas.

To conclude, we can consider across this first section that external users are recognized as a potential source of innovation, specifically the one labeled as lead user. Although the innovation stream of literature consequently increases our knowledge on these rare subjects, past research also emphasized some limitations. In particular little is known on how to detect lead users in a context of open challenges, while it occurs to be an efficient way to gather innovative ideas.

Our contribution is to build on these two streams of literature (i.e. Innovation and IS) in order to contribute to fill this gap. Our first study is drawn around this purpose as it aims to answer the following research question: how to detect lead user on ideation platform? Through this question, our paper explores 1) the actors as a source of innovation and 2) tools that enables to gather innovation. As this study deals with both actors and tools, we propose to firstly present the aspect of this study related to the actors and how it contributes challenges identified from lead users stream of literature. This contribution is presented in the next section: presentation of study one.

Study 1: Identifying Lead Users Online: A study of a co-creation platform

1. Response to Challenges

Literature review in Axe 1 addressed several research challenges that we aim to answer across study 1 as discussed below.

Concerning user innovation stream of literature and especially lead user theories (von Hippel 1986), we identified that:

1. Lead user methods are costly, time consuming and difficult to implement

2. Lead user are rare subjects, difficult to detect in mass-market

3. Studies on lead user only investigated offline context

As previously evocated, one possible answer to these challenges is to involve lead users in the online idea generation process through the format of open-call (Spann et al. 2009). Thus, we propose here to cross these two streams of literature - lead user detection and the online context - by exploring lead users in online context, and go deeper on lead users characteristics in this specific context.

As a result, **Study 1 aims to reinforce our understanding of Lead user characteristics by investigating the two following research questions: which characteristics distinguish online lead users who are involved in a co-creation platform, and how to detect them?**

In order to answer these questions, we build on lead users theory that we applied in an online context: an ideation contest. We thus investigate lead users characteristics including challenge-related context, in order to address an online typology of lead users and better known the actors of innovation in this specific context.

From a theoretical perspective, our study is the first that investigate the lead user detection during online ideation challenge and provides useful insights by building a typology of the online lead user characteristics. This typology might advance theoretical knowledge on user innovation by extending existing research to another underexplored context. Furthermore, an online lead users typology would help firms to better identify these rare subjects and consequently increase likelihood to catch ideas with higher innovation level and more commercially attractive.

2. Research Design

In order to study lead user detection and characteristics during ideation challenge, we followed a research protocol on three steps (figure 3) that we describe bellow.

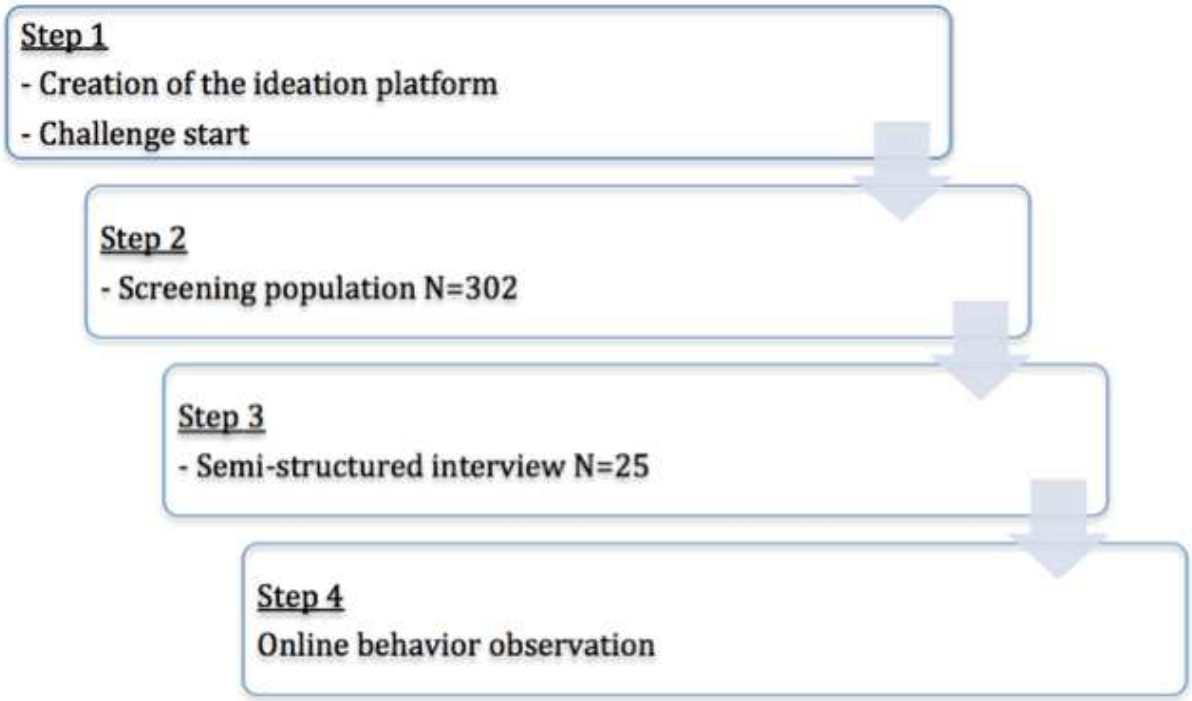


Figure 3: Research Protocol

- Step 1

The first step started at an early stage of the paper development as it was aimed to develop our own ideation platform[2]. The Minder Platform was created in an experimental context following a professional project for Montpellier Business School. We thus decided to use this opportunity to create a research field suitable to advance our idea of studying online lead users detection.

- Step 2

The second step was to screen a population of 302 participants engaging on the minder Platform. Indeed, we built on lead user characteristics literature (e.g. Morrison et al. 2000; Luthje 2004; Hienerth et al. 2007) as already discussed in axe 1, and applied screening methods to our context. We thus screened all participants with an online questionnaire (directly on the platform) in order to identify and to pre-select potential innovative users.

[2] More details on Minder Platform are available at: www.innovation-minder.com

- Step 3

After having selected 25 potential innovative participants from the screening step, we deeply explored the characteristics of these participants in order to identify potential lead users and better understanding their online profile. Thus, we conducted in-depth interviews to validate the characteristics of online lead users and confirm the lead user status of these 25 participants. Then, we used a computer-supported qualitative data analysis tool, NVivo, to manage the data analysis process. During the coding process, data items were generated that ranged in length from a few words up to several paragraphs. We used the previous lead user literature to construct a terminology and to find definitions to describe our codes and themes. In analyzing the data of a specific participants' profile, we considered each lead user attribute and the corresponding characteristics separately to provide a detailed overview of the typology of these online characteristics. For each respondent, we identified several attributes of lead user characteristics, and we constructed a theoretical perspective related to the previous literature. We grouped these attributes together using ahead of trend, consumer knowledge and expected benefit as metrics.

3. Results

Our results reveal some variations concerning the three main variables compared to existing literature. Meaning we cannot just stick to the main definition of lead user characteristics, we need to complete them and adapt them to the online context (table 4):

- Lead users do not need to expert on the product or to have an extensive knowledge on the product, but their knowledge on the product family is enough to make them a lead user and give the expected added value for firms.
- We observed that Lead users do not need to feel dissatisfy or present existing need to propose innovative solutions to product improvement.
- Lead users do not have to be connected and filled each day by forum, group of interest in the specific product, but they look for information when they need it as they know where to look for it.

Offline Characteristics		**Online characteristics**
Ahead of trend (Von Hippel, 1986)	Evolution to the online context (Potz and Schreier, 2012; Spann et al., 2009)	Ahead of trend - cutting edge position - opinion leadership behavior
Opinion Leadership (Franke and Shah, 2003)		
Use experience (Hienerth et al. 2007)		Consumer Knowledge - Technical knowledge and experience with respect to the overall field-related product
Product-related knowledge (Morrison et al. 2004)		
Expected benefit (Von Hippel, 1986)		Need for Innovation - Challenge-related need for innovation
Involvement (Luthje, 2003)		

Table 4: Typology of online lead users characteristics

Axe 2 – Tools as a Mean to Co-Create

In this part, we will first present research interest of studying the tools as a mean to co-create. Second, we will address theoretical background related to ideation platform and Open Source Software. Third, we will discuss research challenges highlighting the needs for further investigations for the two studied tools. Then, we will present answers to these challenges by introducing study 1 and study 2.

1. Research Interest

While it is now admitted that firms rely on external users to foster innovation, a new paradigm emerges as a channel for organizational innovations. This paradigm is labeled by Howe (2006) as crowdsourcing and defined as a type of participative activities engaging a large group of individuals to voluntary accomplish a task to a predetermined goal (Majchrzak & Malhotra 2013). Numerous practical success have led scholars to examine the crowdsourcing phenomenon to better understand its functioning, stakes and implications, for theory and practice. For example, Dell (in February 2007) has launched an open call initiative i.e. IdeaStorm, an ideation platform that allows individuals all around the world to post ideas or comments. The company invites people to improve product or answer specific problems through its own online platform. As a result, Dell has implemented nearly 200 of the 10,000 or so ideas that have been posted on IdeaStorm (see IdeaStorm.com).
This success demonstrates the importance of collaborative tools to support and facilitate new forms of interactive activities (Majchrzak & Malhotra 2013), and set off strong interests for academic research.

First, there is a need to explore the specificities of participants' behavior (Lakhani & von Hippel 2003), the way of how knowledge is created (Franzoni & Sauermann 2014), and most important, how do creative ideas come up from crowdsourcing (Toubia 2006).
Second, academics aimed to focus on the different methods and techniques that enable to 'crowdsource' a problem. Past research demonstrate that toolkits for user innovation are not only developed for a few types of specific industrial product, but could serve as a valuable new product development method for all product types or services (von Hippel & Katz 2002).

As a result, the emergence of crowdsourcing phenomenon highlights several stakes that need to be undertaken regarding both the actors and tools:

- How crowdsourcing enables idea generation?
- Which are the tools that allow to gather ideas?
- How tools can lead to improve creativity?

Most of the time, new product development follows a stage-gate process, starting with the idea generation phase, following by idea implementation and ending with the launch of new products. Across these different phases, the company works with specific guidelines for passing through these stage gates (Salter et al. 2014). However, the use of crowdsourcing techniques questioned the way one considers process of idea generation, as it totally redefines the innovation model, from closed to open (Chesbrough 2003), by inviting external individuals to generate ideas. The first question is related to this concern.

The second question refers to the means that enable the search for innovation via crowdsourcing techniques. To answer this question, innovation literature proposes that a *toolkits approach* must be considered. The toolkits approach involves the transfer of need-related product development tasks from manufacturers to users (von Hippel & Katz 2002), via virtual tools. Numerous web-based tools have been showed as innovation facilitators and allow various forms of interactions. We focus here on two different tools: the Open Source Software (OSS) and Ideation Platforms. The reason of these choices found its origins from salient practical success that considerably increase research interest for these tools. We before mentioned the case of Dell and IdeaStorm platform to demonstrate the ideation platform efficiency, and other examples strengthen this assumption. Paal Smith-Meyers, Head of New Business Development at LEGO, explains that 90% of their customers want to custom products. Even if only 1% has the required skills, with a consumer based of 32 millions, it represents more than 3000 people who can potentially develop innovative ideas (Jensen et al. 2014). With the LEGO Design ideation platform (launched in 2008), the company experimented selling products completely designed by customers. Ideation platforms represent a very interesting “partner” to gather ideas and to interact with potential innovative users.

Furthermore, the Open Source Software is also representative of recent web-based success. Since several years, OSS have been widely adopted for different purposes. For example the

success of Apache with more than 65% of public websites blocked by this web servers (von Krogh 2003) or Linux with a nearly 40% of large American corporations who use this operating system (Bagozzi & Dholakia 2006), increase both managerial and academic interest.

Finally, we saw in the previous section that lead users are positioned to be active customers/users who can provide innovative ideas. However, little is known on how these subjects can react in this specific online context and how web-based tools enable to detect or even increase user innovativeness.

Thus, the following parts are dedicated to first, define the concept of crowdsourcing to promote idea generation and second the identified tools –ideation platform and OSS- as means to crowdsource a problem and enhance user innovation. Third, we develop the underlying research challenges and finally, we present our contributions to these challenges across two studies.

2. Defining Concepts

2.1. Generate idea from crowdsourcing

2.1.1. *A definition of crowdsourcing*

Howe (2006) describes crowdsourcing as a new web-based business model that harnesses the creative solutions of a distributed network of individuals through an open call for proposals. Following a particular process as illustrated in figure 4, crowdsourcing can achieve different goals and generate different outputs.

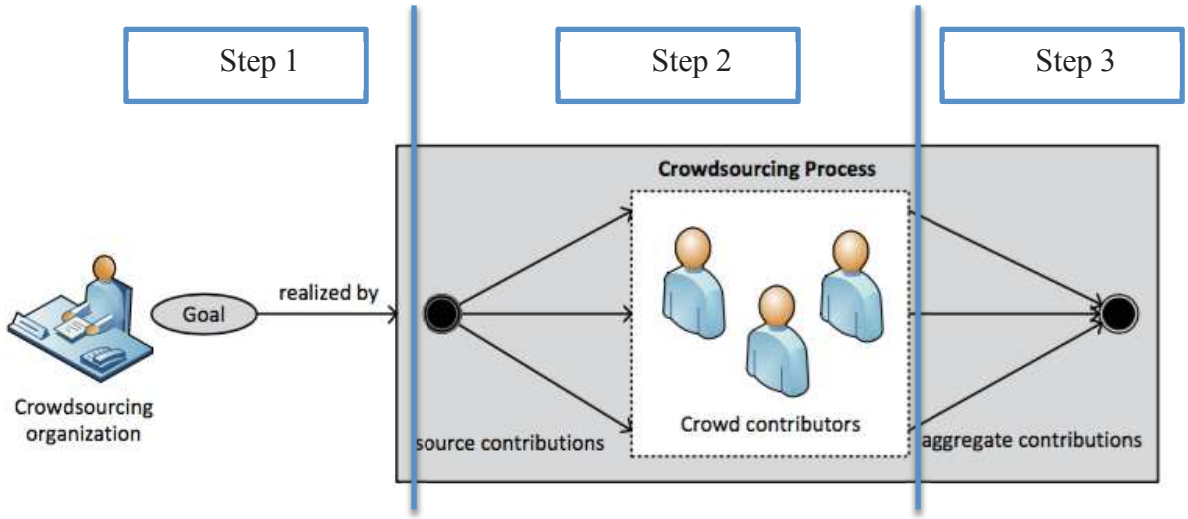


Figure 4: Crowdsourcing approach (adapted from Geiger et al. 2011)

First, firms identify a problem to be solved and transform it into a form of open call or challenge to introduce to the crowd with an identified goal. Second, firms source contributions from the crowd directly on a web-based tool. Concerning the third phase, it could vary, depending on the targeted goal. In the case of Amazon for example, the crowd is asked to provide reviews for products. Thus, contributions are aggregated in an integrative approach (Geiger et al. 2011). However, if we consider the example of Threadless or IdeaStorm, contributions are aggregated in a selective approach (Geiger et al. 2011). In other words, through a selection process and depending on the number of votes, the firm selects one or several promising ideas to entail a new product development process.

According to Surowiecki (2004), the web provides the right conditions to enhance a collective intelligence superior than smartest people individually. This phenomenon has been labeled "crowd wisdom" and qualifies the huge potential of how so many dispersed individuals excel

at singular, sometimes in highly complex problems when traditional problem-solving teams cannot (Brabham 2008).

First, geographical distance of individuals involved in a common task resolution leads to facilitate exchanges from diverse backgrounds, opinions, culture and skills (Chua et al. 2015; Cyr 2008) and increases likelihood to generate innovative ideas. In the crowdsourcing context, virtual co-creation experiences may have the potential to create the right environment to develop participants' willingness to share knowledge and solve problem in a more creative way. However, depending on the desired solutions, the target audience and the problem itself, firms have to pay attention on how the virtual experience are designed (Garcia Martinez 2015; Afuah & Tucci 2012).

Second, previous literature (e.g., Franke & Shah, 2003; Jeppensen & Frenderiksen, 2006; Lakhani & von Hippel, 2003; von Hippel & von Krogh 2003) has shown that the underlying motives for individuals to participate in collective innovation processes are informed by a mix of intrinsic and extrinsic rewards and that these motives are encouraged by toolkits for user-generated design (Jensen et al., 2014). Open challenges induced by crowdsourcing the context specificities aggregate the required conditions to combine intrinsic and extrinsic motivations for participants to enhance idea generation.

2.1.2. *How to generate ideas from the crowd*

In order to better understand how the crowd could generate innovative ideas, we need to focus on the individual level. Actually, we need to understand how people have or even develop creative skills in this specific context. Following Amabile et al. (1996), creative ideas are recognized as creative when they are novel and potentially useful for an organization. Novel means that ideas are new and different from other available ideas, and useful mean that it will increase firms benefits in any sense (Shalley et al. 2004). However, not all the ideas posted in a crowdsourcing platform are creative.

Contextual factors have been fully investigated in management literature in order to explain their potential impact on creativity (e.g. Zhou & Oldham 2001). Some of these factors can be linked to the crowdsourcing context and will define the right conditions to enhance innovation.

As we saw before, crowdsourcing often takes a form of open call, whereby the seeker rewards the winner solutions. In management literature, a reward system such as monetary systems has been positively associated with a higher level of creativity (e.g. Eisenberger, 2001). In IS

and innovation literature, some research demonstrate that challenge-related tasks, including rewards for the winner solutions, also positively impact the creativity of participants. These motivational factors, intrinsic, as well as intrinsic, are both directly induce bth idea-competition tasks. For example, Leimeister et al. (2009) evaluate the participation activation process during an ideation contest. The authors found that incentives and motives of users are both influencing factors of the users participation and creativity. The authors demonstrate, in this context, that learning (e.g. "access to knowledge"), direct compensation (e.g. "prizes") and social motives (e.g. "appreciation by peers") lead to enhance participants' creativity. Other research found that personal satisfaction in seeing ideas adopted by firms (Boudreau & Lakhani 2009) and recognition from the crowd or the organization, increase the level of innovations (Jeppesen & Frederiksen 2006).

In other words, crowdsourcing sets up a context-related environment that creates the "right conditions" to foster ideas generation. In addition to the motivational and incentives factors offered by open challenges, other factors have been identified. As explained, ideation contest calls for individuals to submit ideas on a specific task. At early stages of the process, participants independently post ideas. Nevertheless, they can later have interactions and improve together individual submissions, as participants are often required to comment and vote other ideas. Thus, participants first work alone and then work together. Girotra et al. (2010) qualify this process as "hybrid" process and demonstrate that "groups employing the hybrid process are able to generate more ideas, to generate better ideas, and to better discern their best ideas compared to teams that rely purely on group work". In IS literature this process has been experimented as "generative for co-creation". This phenomenon is defined as a series of interactions whereby individuals discuss on the different assumptions in order to solve critical problems (Majchrzak & Malhotra 2013; Tsoukas 2009). Majchrzak et al. (2012) explained that these collaborative tasks allow individuals to jointly share knowledge and modify idea to « co-create » solutions with higher creative potential. The crowdsourcing environment and the design of the crowdsourcing process itself allow to develop such a "generative co-creation" process that positively influences ideas generation (Poetz & Schreier 2012).

As a result, we can argue that crowdsourcing tasks are recognized as a promising tool to strengthen idea generation process from external individuals. In order to concretely materialize and empirically explore this process, we propose to focus on two crowdsourcing

tools: ideation platforms and Open Source Software. The next parts describe these tools to better understand the underlying mechanism.

2.2. Ideation Platform

When companies decide to outsource a problem or a task and to collect ideas from customers, one of the most used tools is an Internet-based platform. Ideas are submitted directly on the Internet through different stages from idea submission to idea selection (figure 5).

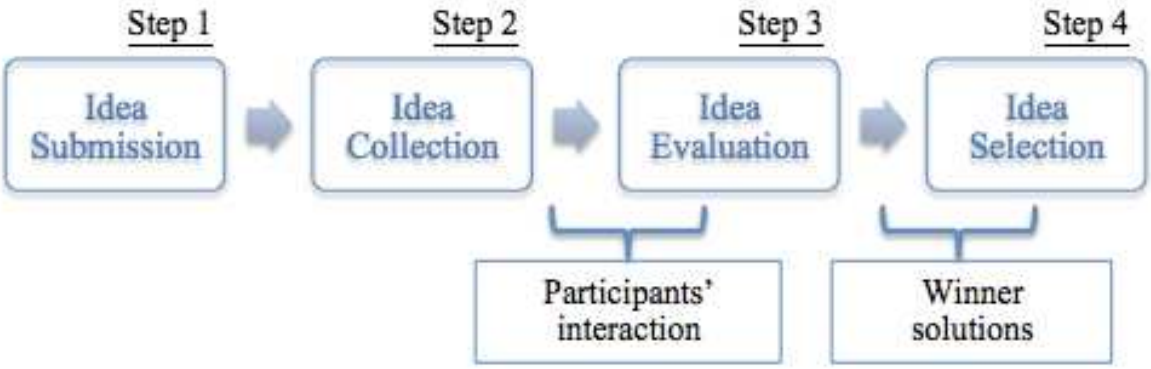


Figure 5: Process of idea selection during ideation contest

In a first step, participants propose one or several ideas that submit on the platform. At this point companies gather a huge amount of ideas and start the second step by collecting these ideas through the Internet platform. Between step 2 and step 3, participants can interact each other as they can comments and vote on ideas of others. This phase of interactions among participants is typically recognized to enhance a "generative for co-creation process". As the crowd is asked to vote and comment other ideas, most popular ideas often come after many recombination that are particularly generative (Majchrzak & Malhotra 2013).

Then, according to participants' votes company can evaluate potential ideas, which provides an important early assessment regarding the potential of the proposed ideas (Huang et al. 2014). Finally the company or an expert panel can select the most promising one.

In order to understand this process, various studies explore and describe real-word ideation platform. A very famous example is the IdeaStorm, Dell's collaborative platform (e.g. Bayus 2013; Li & Kim 2010; Di Gangi & Wasko 2009; Gallaugher & Ransbotham 2010). Through IdeaStorm (figure 6), users have to first create an account and complete a user profile.

Then participants can access ideas submission page and propose an idea with a brief description. Once the idea posted, the ideation process goes through idea rating, and users are able to vote other ideas "signaling ever it should or should not be adopted by Dell"(Gallaugher & Ransbotham 2010).

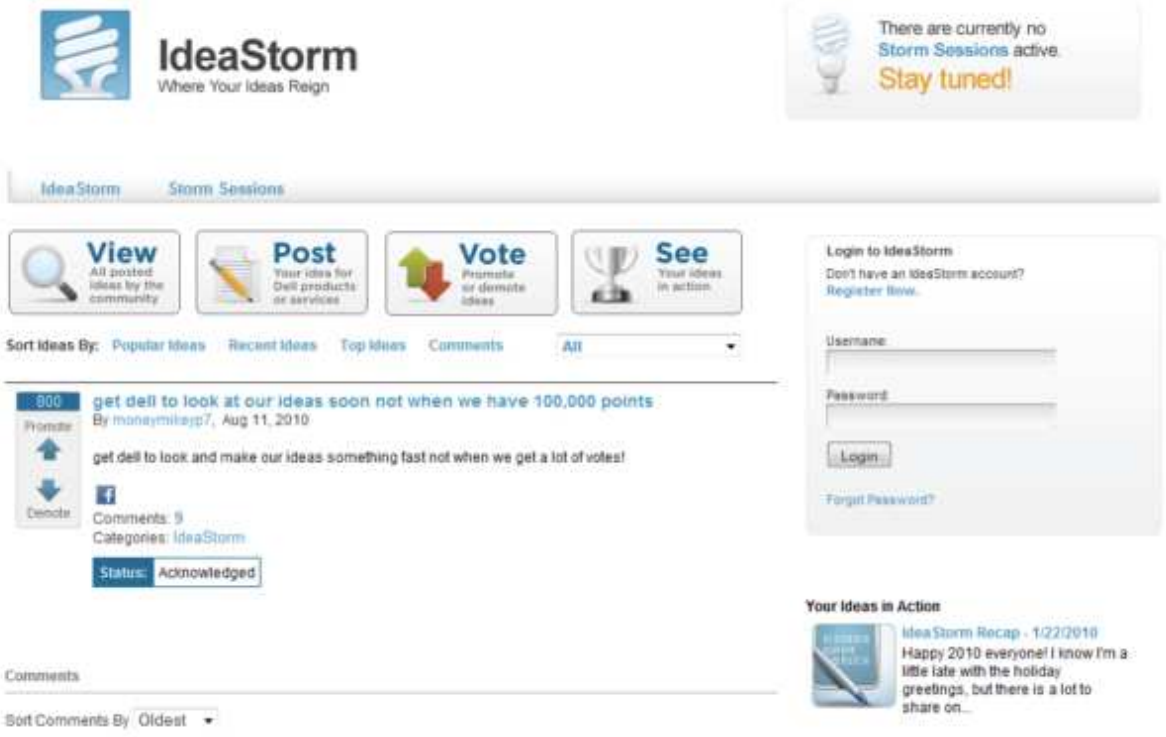


Figure 6: Dell Ideastorm homepage (Source: http://www.ideastorm.com)

Ideas with the most important number of votes are available directly on the homepage of IdeaStorm included for non-participants (figure 7), meaning that all Internet users who visit the company website have a direct access to the top contributions designed by users.

Figure 7: Top contributions (Source: http://www.ideastorm.com)

Internet-based toolkits for idea competition are thus a novel way for firms to access ideas from users. An ideation platform allows firms to directly interact with external participants and facilitates interactions among users as well. The tool configuration provides opportunities for customers to learn from other customers and helps them in suggesting better ideas for firm to implement (Huang et al. 2014).

Toolkits for innovation offer many possibilities for firms as well as customers to attempt a win-win situation. Firms can benefit from the value of the solution, when customers can enjoy the use of better products or added features. Fitzgerald (2006) explains that the free software movement also allows to create valuable solutions as it represents a platform used by firms to generate additional value. Therefore, we propose to examine this phenomenon for deepen our understanding of tools as mean to create innovation.

2.3. Open Source Software

The open source software movement has fundamentally revolutionized the way to develop software, as the source code of products is freely available for anyone who is motivated to improve, modify or develop the quality of software products (von Krogh & von Hippel 2006; Fitzgerald 2006). This movement offers opportunities to quickly and at lower costs develop higher quality software (Sharma et al. 2002), beside a more flexible technology and quicker innovation.

Specificities of OSS reside in contributions from individual users motivated to answer an individual need that often represents common needs among other product users (Franke & von Hippel 2003). In other words, firms do not directly control resources and necessary skills. Instead, these resources reside in more informational structure among OSS communities that "co-exist with the firm" (Dahlander & Magnusson 2005). The specific process of OSS allows a form of co-development among firms and users that fosters innovation (figure 8).

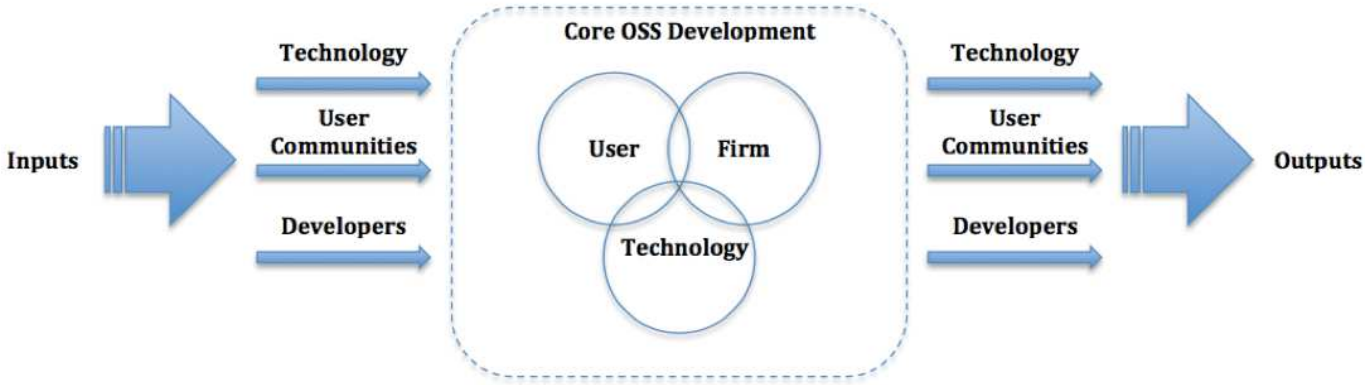


Figure 8: Open Source Process (Adapted from Aksulu & Wade 2010)

First, absence of temporal and spatial limitations raises opportunities for interactions among users' communities, developers and technology, from inputs to outputs development. Indeed, OSS systems operate in an environment whereby boundaries are almost transparent, allowing for numerous opportunities for multi-level interactions between the system and the surrounding environment (Aksulu & Wade 2010). Boundaries freedom offers opportunities for better communication channels and hierarchical flexibility, leading to higher levels of effectiveness and innovation (Stewart & Gosain 2006).

Second, the OSS system finds its particularity in "lifespan" specificities (Aksulu & Wade 2010). As illustrated in figure 8, rather than having an externally defined lifespan the OSS system remains active as long as one person internally, as well as externally, continues to maintain it (Shah 2006).

Third, objectives of a project are rarely defined at an early stage, but tend to evolve in an unpredictable manner as long as the projects is developed, mostly depending on participants related needs (Lee & Davis 2003).

Finally, figure 8 shows that outputs of an OSS project include the users' community, developers and the technology itself. This multi-level co-development gives the possibilities to ensure skills development of people involved and produce technology improvement, even if the final output resulting from this system is not a tangible technology (Aksulu & Wade 2010).

As a result, scholars start to investigate the OSS movement through some of the iconic products, such as Linux, Mozilla, Apache or MySQL in order to understand why this tool became so successful and how it may lead to increase firms' innovativeness.
The open innovation stream helps to understand the rise of open source software (West & Gallagher 2006). As we saw before, boundaries openness of OSS systems allows to develop an open culture (von Hippel, 2001), which is an essential element in the rise of innovation. It facilitates the means to share knowledge among communities (e.g. Feller and Fitzgerald, 2002) and to grasp new sources of innovation (von Krogh and von Hippel, 2006) according to the assumption that all skills and ideas do not reside within the firm.

In the case of OSS, elements of the toolkit required to design and modify the product are available for free to the user community, which widely facilitates user participation and motivation to engage efforts in product development. Apache for example created the Apache Development Foundation whereby community of user volunteers directly work on projects. This tool was demonstrated to widely facilitate product improvement by users, and most important, allows to better activate innovation diffusion (Franke & von Hippel 2003). Market research explain that user needs, skills and interactions are heterogeneous and difficult for a firm to fully satisfy (e.g. Prahalad & Ramaswamy 2004b). In their study of Apache systems, Franke and von Hippel (2003) found that only 37% of users had the needed skills to write new code, but they also discovered that 64% had the skills needed to download and use the new code previously developed. In other words, the toolkit approach developed by Apache offers firm opportunities for first, satisfy skilled user by allowing them to answer themselves their need; and second for satisfy the widespread of other user within the community by improving the fit between a product and the heterogeneous needs of individual users.
The network ties (Peng et al. 2013), coming from co-membership of project teams, is the essence of OSS mechanisms leading to an efficient value creation process. Thus, the OSS development approach represents an efficient tool compared with more traditional approaches, by implementing concurrent design and testing of software modules (Sen et al.

2012). Built on network ties, OSS movement allows sharing knowledge and expertise within user communities, which contributes to the success of this tool and provides potential to increase firms' innovativeness.

3. Challenges for Research

This second axe aimed to explore how IT tools could represent an efficient mean to create innovation from external sources. Depending on the problem type and the knowledge required, firms may choose to crowdsource a problem and to obtain potential solutions from external users or customers (Afuah & Tucci 2012). In order to better understand how external ideas are generated, we focused on two specific tools – ideation platforms and Open Source Software. While academic research has demonstrated that these tools allow the production of innovative outputs, several limitations still remain.

3.1. Challenges related to design of ideation platforms

Ideation platforms have been recognized as an efficient tool to collect and diffuse innovative ideas. However, several points demand for further considerations and investigations.
Past research acknowledged that the performance of an idea generation should be largely influenced by the procedure of idea evaluation (Piller & Walcher 2006). Specifically, one of the most important issues is that when firms rely on user innovation, it has to deal with "too many ideas" (e.g. Peppard et al. 2011; Yoo et al. 2012). Indeed, although a firm is able to set up an efficient idea generation, the next step is to identify and filter those with the highest potential. While we previously saw that users assessment through a system of votes considerably reduces costs regarding idea selection, academics commonly acknowledge that "it would be unreasonable to ask each consumer to evaluate more than a few ideas" (Toubia & Flores 2007). Indeed some research observed that when users are engaged in too many activities (ideation, design and evaluation) and play too many roles, it tends to decrease the likelihood for firms to find commercially attractive ideas (Jensen et al. 2014).

One possible answer to this issue is related to the design of the platform itself. Firms may take advantage of struggling on designing a crowdsourcing platform to create filtering methods that enable "crowdsourcers" to eliminate weak contributions at a early stage of the idea generation process (Peppard et al. 2011). However, empirical research to date tends to demonstrate that idea evaluation among users arrives at the last stage of the idea generation process. Thus, it might be useful for research and practice to evaluate if such conditions could lead to improve the selection of higher idea quality.

3.2. Challenges related to OSS performance

As we suggested in this section, notable success of OSS product such as Linux or Apache have increased academic interest (von Hippel & von Krogh, 2003; Crowston et al. 2012) to understand its functioning and how it allows firms to leverage innovation from users. Scholars commonly acknowledged that one of the explanation of OSS success resides in the huge interactions between users and developers, allowing to share knowledge, expertise and increase user satisfaction (e.g. Sutanto et al. 2014).

However, academics also recognized that failure rate of OSS still remains important and recommend deeper investigations of OSS success factors (Fitzgerald 2006). Specifically, academics argue that a better understanding of nature of interactions among OSS participants should be a possible answer. Indeed, managing information exchange between contributors (Peppard et al. 2011) will help answer this issue. Nevertheless, research to date mostly focused on the antecedents of these interactions as for example the role of developers (Ghapanchi 2013), the role of users (Iivari 2009; 2010), or the contributions of these actors such as the level of activities (Crowston et al. 2006). Academics recognized that developers and users have both very identified roles in the OSS project development and have a considerable impact on projects performance. Particularly, it has been proved that users interest and involvement, as well as users communication about an OSS project, have a positive impact on OSS popularity (Ghapanchi 2013). In other words, the interactions between users and developers may reinforce the mutual adaptation that occurs during project development to meet users' expectations.

However, few studies to date have examined the nature of the interactions between OSS participants, whereas a better understanding of these interactions might help firms to avoid projects failure.

Furthermore, many studies examined internal factors such as OSS license (Comino et al. 2007), software quality (Crowston & Scozzi 2002) or developers motivations (Meissonier et al. 2010), as well as external factors such as network particularities (Grewal et al. 2006) or users interest (von Krogh & von Hippel 2006), and evaluated their impact on OSS success.

However, the definition of success is highly controversial, having different meanings across projects and stakeholders (Crowston et al., 2003), and previous studies commonly acknowledged that the success of OSS projects could be interpreted in different ways (Crowston and Scozzi, 2002). In addition, Grewal et al. (2006) explain that measuring success

of OSS projects in terms of technical achievements or market success represents an incomplete picture of success.

To conclude, the purpose of these two first axes was to investigate 1) the actors and their role in the external innovation process and 2) the tools as mean to gather innovations from external sources.

In the first axe, based on the user innovation stream of literature, we saw that specific actors labeled as lead users represent a salient source of innovation with high potential to product creative and innovative ideas.

In the second axe, based on the crowdsourcing stream of literature, we saw that firms can grasp innovation solutions by crowdsourcing the problem. We focused on two specific tools – ideation platform and Open Source Software – and considered that these tools represent valuable means for firms to gather innovation when outsourcing idea generation process.

Furthermore, a deeper investigation of these streams of literature allowed us to detect challenges for research and gaps that need to be answered. First, while firms widely rely on ideation platforms to outsource a problem, little is known on how this tool has to be designed in order to improve the production on innovative ideas. Second, while OSS allow for generate innovations; the notion of success is still confused, specifically in the way to apprehend the nature of contributors' interactions.

We aim to add our contribution across two studies by exploring these gaps. Hence, while we have already presented study 1 to answer challenges related to the actors, we will now present this study from an IT tool point of view. Hence, as this study in positioned around an online ideation platform i.e. The Minder Platform, we will show how it allows to answer tools-related challenges previously evocated.

Our second paper specifically focuses on the OSS tool and aims to deeper explore the information exchange among contributors and the impact on tool's performance by addressing the following research question: does the combined effect of user-developer interaction and market potential lead to greater OSS popularity?

The next part is dedicated to present study 1 and study 2.

Study 1: Identifying Lead Users Online: A study of a co-creation platform

1. Response to Challenges

Literature review in Axe 2 addressed several research challenges that we aim to answer across study 1 as discussed below.

Indeed, concerning crowdsourcing stream of literature, we observed that various studies started to investigate crowdsourcing techniques as a mean to gather innovation (Howe 2008), as ideation platform. However, we identified two main challenges related to this tool:

1. Firms have to deal with too many ideas

2. Need to improve idea selection process

As previously evocated, we identified that an open-call has to answer several conditions in order to make the search for solutions effective. First, the design of the platform should considerably impact participants interactions and thus promote creativity (Kim et al. 2016). Second, participants should be able to assess more than "few ideas" to improve selection process (Toubia & Flores 2007)

As a result, **Study 1 aims to reinforce our understanding on how ideation could represent an efficient tool to boost co-creation activities?**

2. Research design

As previously explained, we followed a research protocol on three steps to investigate the online detection of lead users. We will focus here on the first step of this protocol, the Minder platform creation (Figure 9)

- Step 1

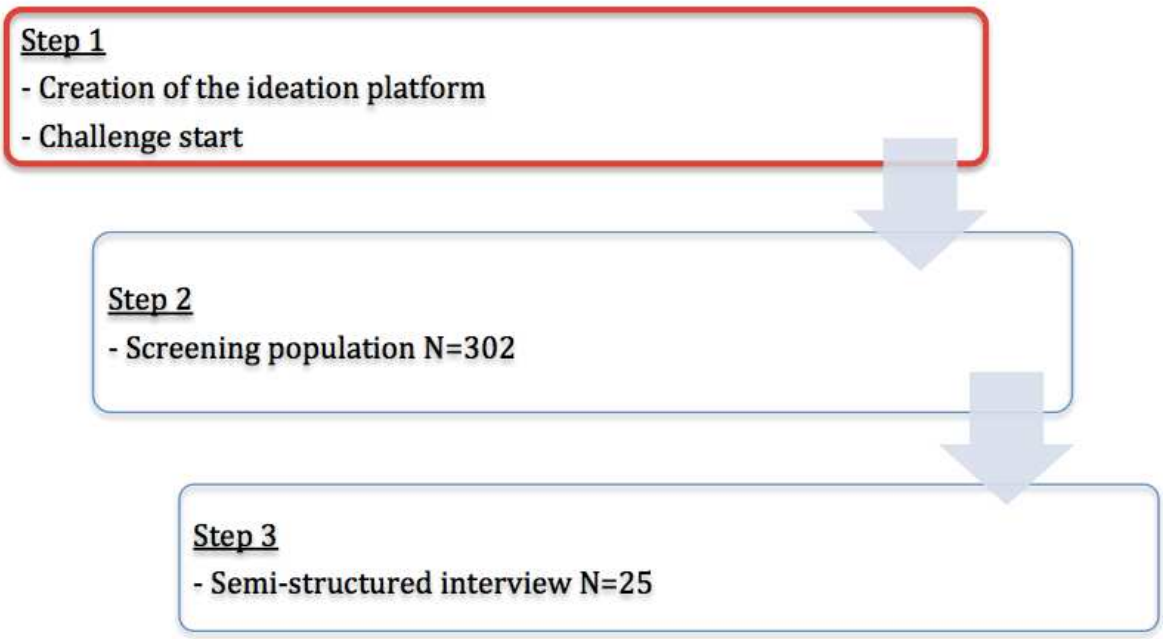


Figure 9: Focus on platform creation

As previously evocated, The Minder Platform was created in an experimental context following a professional project for Montpellier Business School. In order to explore the question of how tool and challenge designs could enhance participants' creativity, we thus developed the platform with the objective to aggregate the required conditions to enhance effective idea generation process:

- Create an open call:

In order to increase user participation and develop motivation incentives environment (Boudreau & Lakhani 2009; Leimeister et al. 2009), we introduced a problem to the crowd in the form of open challenge asking participants to "Invent the next tablet generation". The contributors were informed in advance that the winner solution will received a price (a Samsung tactile tablet).

- Create participants interactions:

In order to produce "generative for co-creation" process (Majchrzak & Malhotra 2013), we develop a specific design (figure 10, figure 11) to allow interactions among participants, whereby they were involved during the entire idea generation process.

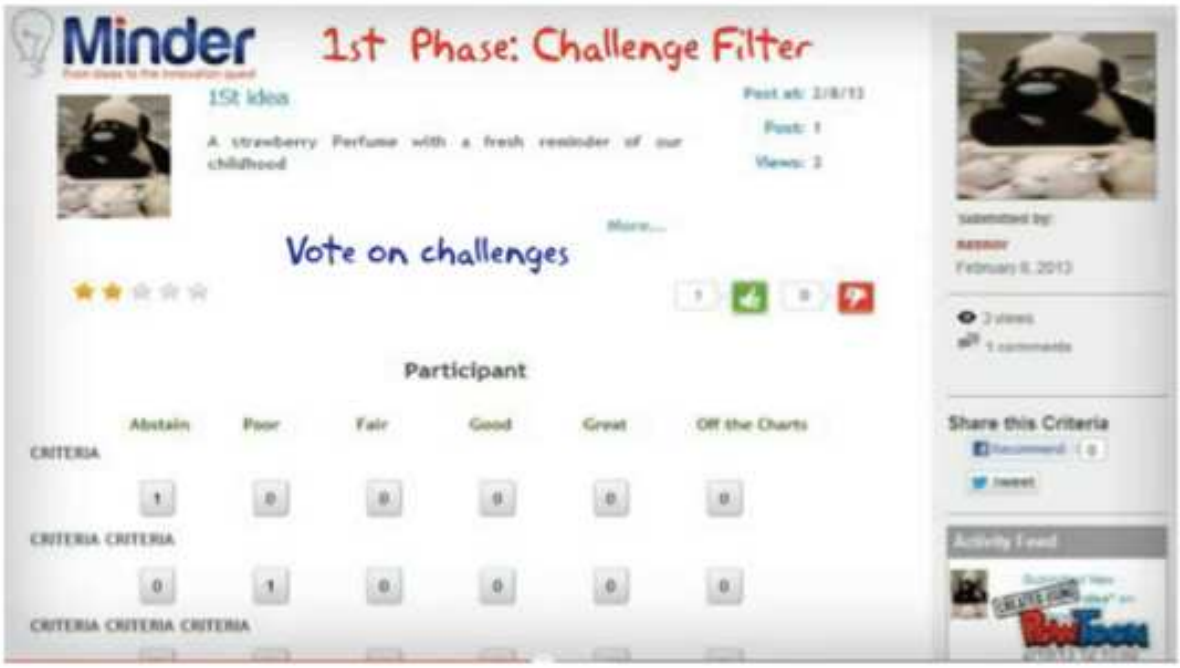


Figure 10: Screenshot of Minder Platform - votes page

Indeed, participants were asked to comment, vote and rate potential ideas at each step of the ideation process, from potential idea selection to final concept selection

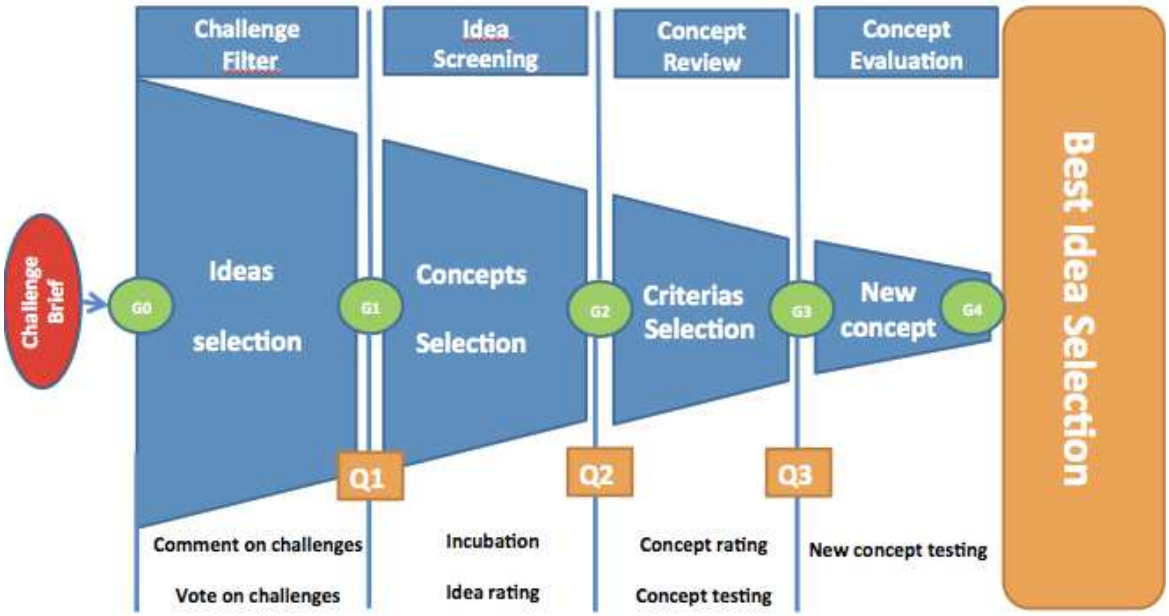


Figure 11: idea selection process and participants assignments

3. Results

Our result previously evocated and precisely the in-depth interviews demonstrate that innovative user, lead users, do not show the same characteristics offline and online. Particularly, emergence of creative ideas is more linked with challenge-related motivations. In other words, specific conditions of ideation platform increase participants' creativity thanks to challenges-related motivations.

Study 2: OSS Popularity: Understanding the Relationship between User-Developer Interaction, Market Potential and Development Stage

1. Response to Challenges

We observed in axe 2 that because Open Source Software system allows 1) strong interactions among members, 2) having free access to the source code and 3) sharing knowledge and expertise, literature on innovation and information systems commonly acknowledged that this tool is widely related to the creation of creative outputs (e.g. Peng et al. 2013; Sen et al. 2012; Toral et al. 2010).

However, we identified several challenges related to this tool.

First, while scholars recognized a positive impact of network interactions on OSS success (Grewal et al. 2006; Sutanto et al. 2014), the notion OSS success is still (e.g. Crowston et al. 2006) controversial. Second, since famous products such as Apache or Linux have attracted scholars' interest, little attention has been paid to less-well known projects. Thus, we identified a need to:

1. Develop more relevant measure of OSS performance

2. Pay deeper attention to less-well known projects mechanism

To answer these challenges we suggest to build on OSS popularity since it has been proposed as a more valuable indicator of OSS project performance, especially for less-well known project (Stewart & Ammeter 2002; Crowston et al. 2012). Indeed, Crowston (2003) explains that rather than measuring the actual use, particularities of OSS project require measures of input (level of activities), process (speed of bug fixing) and output (popularity) in order to obtain more realistic measure of OSS performance.

Hence, our study 2 aims to investigate popularity as output to measure OSS performance and in order to deeper examine factors allowing to increase OSS popularity. We thus focused on understanding the process explaining OSS popularity by building our model following the overall OSS development process including input, process and output (figure 12).

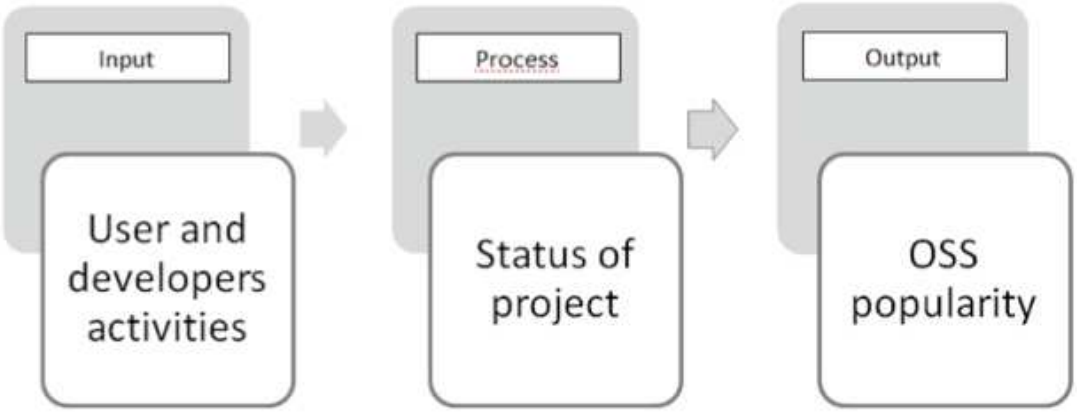


Figure 12: Development process of OSS project

First, the input (Figure 12) considers the relationship between user and developers since successful OSS/technical support—OSS developer support—increases the fit of a project with OSS users and consequently increases OSS popularity (Ghosh et al., 2013). According to existing literature (as mentioned in Axe 2), we thus first rely on the nature of interaction among users and developers by studying the level of information exchange and the nature of these interactions. In addition, according to Ghosh et al. (2013) OSS performance needs to encompass market-based measures in order to evaluate the general level of interest for a given project. In order to evaluate market-interest we focus on market-related measures – number of pages visited and number of pages viewed – as it directly refers to users attractiveness for a project (Grewal et al. 2006).

Second, in order to evaluate the notion of process (Figure 12), we consider the evolution of the project itself. Given the iterative process of an OSS project—owing to the interaction and re-adaption between developers and users based on users' needs—the development stage should also influence OSS popularity because more mature and stable OSS projects should have more views and downloads. We thus consider development stage as driver of OSS popularity.

As a result, we aimed to understand the combined effect of user-developer interactions, the market potential and the development stage and the impact on OSS popularity. Figure 13 presents our research model.

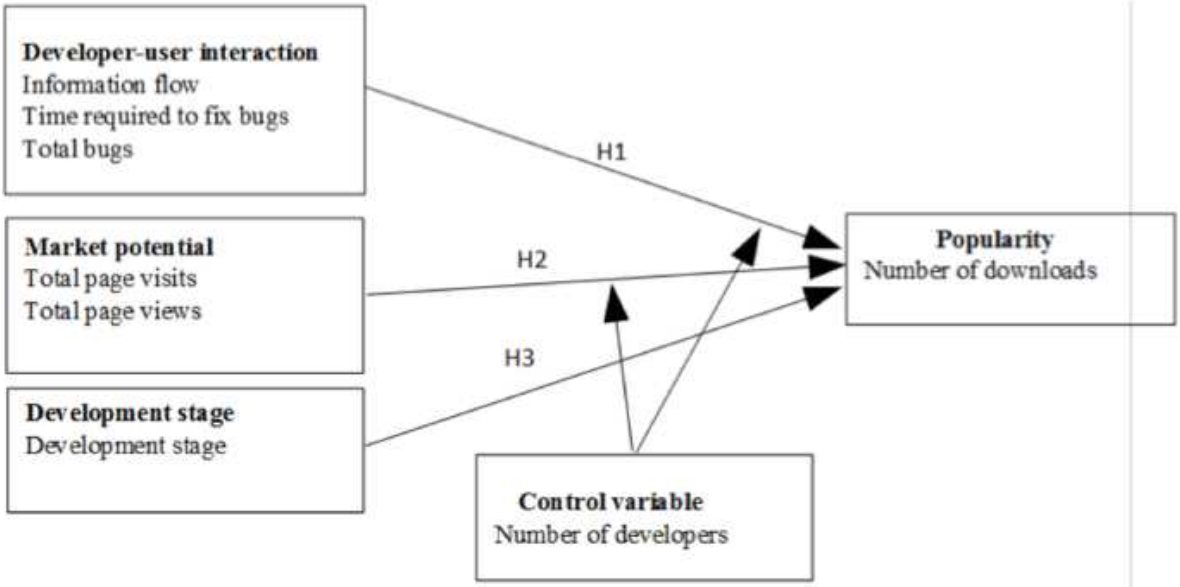


Figure 13: Research Model of OSS popularity

2. Research Design

2.1. Data Collection

We collected data from 657 OSS projects in the SourceForge database. We decided to use one specific category of OSS projects, namely, enterprise applications that were exclusively hosted by the SourceForge website. The subcategory of enterprise applications concerned includes CRM (22%), ERP (33%), business intelligence (17%), data warehousing (15%) and workflow (13%) projects. Our sample offers a considerable variety among projects subcategories, which allows eliminating bias related to a single sample and diversifying analysis.

2.2. Methods

We decided to use PLS regression not only for structural equation modelling but also as a specific regression method for applied management (Tenenhaus 1998) that allows an independent analysis of the variables that can explain OSS project popularity. We used PLS regression mainly to overcome certain constraints of classical linear regression (Wold et al. 1983) and to allow us to simultaneously assess both structural and measurement models (Chin et al. 2003). In addition, the PLS regression method presents many advantages and yields good results not only when data are missing but also when there is collinearity between variables (Tenenhaus 1998).

3. Results

After analyzing the correlation matrix and then verify the presence of collinearity between the variables, using a multivariate regression to assess the collinearity statistics (tolerance and VIF), the VIP (very important variables), the result indicate that all the variables contribute to the phenomenon studied.

In particular, the results reveal that three factors—market potential, developer-user interaction (only for information flow) and development stage—have a positive and significant influence on OSS project popularity. The results specifically show that development stage, information flow (capturing developer-user interaction), total page visits and total page views (both of which capturing market potential) explain 24%, 25%, 19% and 17%, respectively, of OSS project popularity.

Axe 3 – Methods to Optimize the Innovation Process

1. Research Interest

In this part, we will first present research interest of studying the methods to optimize the innovation process. Second we will propose to present and define the concepts of problem solving process and need solution pairs. Finally, we will identify challenges for research and present our contribution to answer these challenges across study 3.

The two first axes were dedicated to explain the roles of both actors and IT tools (i.e. ideation platform and OSS) in the search for external solutions. We explored the process of how to use tools and actors to increase likelihood for a firm to leverage innovative ideas. In other words, we focused on the idea generation process by investigating first, how users can generate creative ideas (Axe 1) and second, how tools can facilitate interactions among users themselves and between users and firms (Axe 2).

However, before outsourcing a problem, firms have to first identify and formulate a problem in order to define how to solve it (Volkema 1983; Afuah & Tucci 2012). Nevertheless, numerous firms are often working on the wrong problem, because they did not adequately define the problem. Spradlin (2012) explains that "when developing new products most companies aren't sufficiently rigorous in defining the problems they're attempting to solve and articulating why those issues are important and without that rigor, organizations miss opportunities, waste resources, and end up pursuing innovation initiatives". Having understood and recognized importance on defining and formulating a problem, scholars widely explored the overall *problem-solving process* to help companies in the search of solution. Problem-solving process is commonly described by a succession of steps which are problem identification (Spradlin, 2012), problem formulation (Simon 1973;Volkema 1983; Lyles & Thomas 1988) and problem-finding (search for solutions) (Lang et al. 1978).

Furthermore, empirical and theoretical research commonly acknowledged that problem formulation (PF) whereby alternatives views of a problem are generated and selected to build the formulation of a problem, does represent a critical first stage of problem solving process. Indeed, the main difficulty of formulating the problem has been brought out by Simon (1973), who draws a crucial distinction between well-structured and ill-structured problems, explaining that only well-structured problems are suitable for algorithmic solution.

While numerous research worked on improving problem-formulation process (e.g. Sheremata 2000; Atuahene-Gima & Wei 2011; Becker et al. 2005), a recent theory comes up with the idea that solutions could be discovered without formulating a problem. Von Hippel & von Krogh (2016) propose that in informal problem solving process, a need and a solution are often discovered together and argued that the discovery of a viable need-solution pairs (NSP) may have advantages over problem solving/initiated methods, and provide more innovative solutions under certain circumstances.

The authors draw on the idea that problem solving process consists of making a link between a specific point on a need landscape and a specific point on a solution landscape and they term these linked points a "need-solution pair." In other words, they argue that in real life, depending on specific environment, solutions often appear before having identified the right problem.

However, due to the novelty of their positioning, von Hippel and von Krogh (2016) recognize that scholars have to learn on how it works and can work in different context and governance and induce that academics may conduct research to understand the principles associated with its mechanism. Any existing studies to date do not support nor the theory or practice of problem solving via identification of need solutions pairs.

As a result, this new phenomenon leads to the emergence of several questions, with both theoretical and managerial concerns:

- How company can optimize problem formulation (PF) process?
- How to define NSP process in practical environments?
- How firms can leverage innovations from NSP discovering process?

Through these questions, we identify the need to improve our knowledge on NSP from a theoretical, as well as managerial perspectives. We first need to deeper understand how NSP phenomenon is applicable in companies. While von Hippel and von Krogh (2016) argue that NSP have the potential to overcome difficulties of formulating a problem, they also acknowledge the need to establish frameworks explaining NSP mechanism. Indeed, the authors positioned their work at the opposite of problem-solving methods. However, in practice, companies have to understand how to make it possible in managerial context. We thus propose to first, identify and determine theoretical framework whereby this method could

be applicable. Second, we aim to determine differences between NSP and PF process in order to explain how companies should "choose" the best way to address a problem. Finally, we previously observed that companies aimed to generate innovative solutions to answer a problem. We thus propose to explore how NSP method could help companies to gather most innovative ideas. In order to answer this point, we argue that we need to consider the idea as the unit of analysis to understand the idea progression process during the idea generation, and how the methods could influence the emergence of creative behavior (Mainemelis 2010).

The two first sections of our research were dedicated to answer the question of "**why to open**" the search of solutions (Afuah & Tucci 2012) and "**where to search**" innovative solutions (Lopez-Vega et al. 2016). The aim of this section is to answer the question of "**how to search**" innovative solutions, specifically which are the best methods (i.e. NSP/problem formulation) to catch the most innovative solutions.

2. Defining Concepts

2.1. Problem-solving process

When companies face a problem, they have to engage into a problem-solving process in order to define and search for a large number of creative and cost-effective ideas which should become implemented solutions in a timely manner (Sheremata 2000). This process goes through different steps (figure 14) from problem identification to problem finding.

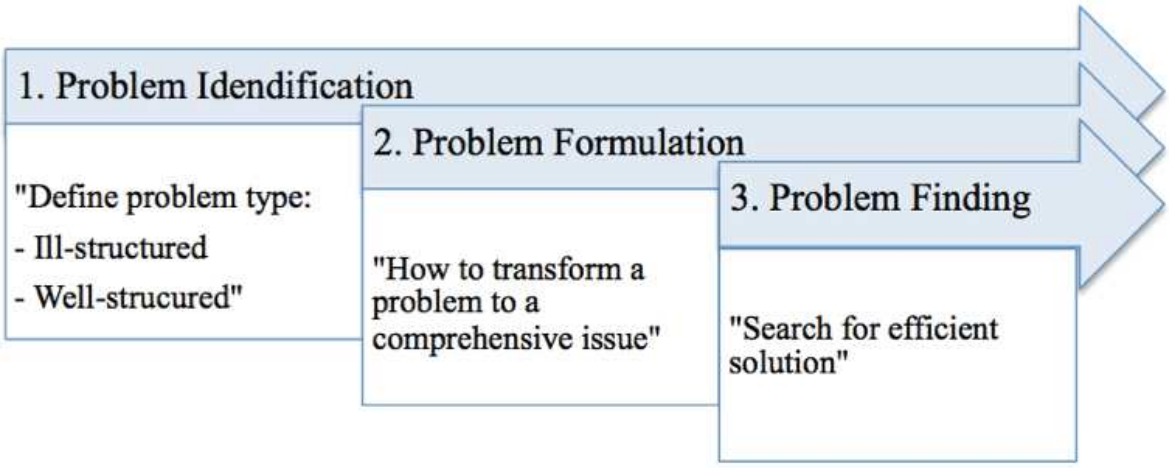


Figure 14: Problem-solving process

The first step, problem identification, relies on the abilities to identify existing problem-related informations allowing to clearly point out a specific problem within an organization (von Hippel & Tyre 1995). The accuracy of information is "largely a function of the firm's prior related knowledge" (Cohen & Levinthal 1990) which influences technical knowledge and capabilities to provide diagnostic (von Hippel & Tyre 1995). While defining a problem is usually listed as the first step of the problem-solving process, this assumption holds both for situations where a problem is identified at the beginning of solving, but also in situations where the initial problem definition is progressively reformulated or re-specified during the problem-solving process (Thomke & Fujimoto 2000). As a result, academics widely investigated the second step, problem formulation, as the critical stage of problem solving process. This step relies on transforming a problem into a comprehensive statement for resolution.

However, academics demonstrated that this transformation could lead to managerial issue. Indeed, the main difficulties of formulating the problem has been brought out by Simon

(1977) who drew a crucial distinction between well-structured and ill-structured problems, explaining that only well-structured problems were suitable for algorithmic solution. Although organizational research worked on convert ill-structured to well-structured problem to optimize the search of solutions, scholars demonstrated that problem reformulation can affect problem solving process in transmitting inaccurate or incomplete information to problem solvers (e.g. Maheswaran & Meyers-levy 1990; Cowan 1990; Sitkin & Weingart 1995, Tyre & von Hippel 1997).

The third step, problem finding, refers to the search for solutions. Literature thus started to investigate factors that influence performance of solutions and the impact of finding effective solutions (Table 5).

Influencing Factors	**Measures of Solutions Performance**	**Output**	**Sources**
Centrifugal forces: Decentralization Free flow of information Reach Centripetal forces: Connectedness Temporal pacing Project leader expertise Superordinate goal	Types solutions founds Problem solving speed Solution quality	Increase product development performance	Sheremata 2000
Expertise and knowledge (tacit or explicit) of the solver Cognitive frames of the agent (priors activities) Use of external resources	Quality of solution Cost of solution Problem Solving speed	Enhance effectiveness of problem solving process	Afuah & Tucci 2012
HR system: Work organization Skill development Incentives Knowledge system: Source of knowledge Communication network	Time to find a solution	Foster problem-solving process and access to solutions	Appleyard et al. 2006

Influencing Factors	**Measures of Solutions Performance**	**Output**	**Sources**
IP controls			
Market knowledge competences: Consumer knowledge competence Competitor knowledge competence Marketing-R&D interface	Problem solving speed Problem solving creativity: solution quality and cost effectiveness	Improve product quality and product innovativeness	Atuahene-Gima & Wei 2011
Use of virtual tools to: Identify a search space Test and evaluate potential solutions	Cost of solutions Speed of testing solutions	Virtual tools lower the cost and increase the speed of testing Solutions.	Becker et al. 2005
Governance choices: Open governance Closed governance	Solution innovativess	Open governance increase chances to reach innovative solutions	Felin & Zenger 2014

Table 5: Factors influence on problem-solving process performance

We specifically focus here on research that studied external factors and their impact on the problem solving process effectiveness. Indeed, as our research is positioned around an open context, we aim to explore problem solving process and related-methods when especially relying on external resources.

A describe in table 5, solution effectiveness is measured by several variables, such as solutions' quality, time to find solutions or cost-related efforts to find solutions. Several studies explored factors influencing solutions effectiveness and observed the impact on the overall problem solving process. For example, Appleyard et al. 2006 found that the incorporation of external knowledge is positively related to superior performance in terms of problem-solving speed. Overall, past research commonly recognized that firms need to balance benefits of openness and costs, in order to improve problem-solving process performance (e.g. Balka et al. 2014).

However, this body of literature allows a better understanding on where to search solutions and why to open firms' boundaries (e.g. Afuah & Tucci, 2012), but does not resolve the issue related to problem formulation step advocated by Simon (1973) (von Hippel & von Krogh 2016; Spradlin 2012) and especially in context of crowdsourcing (Terwiesch & Xu 2008). One possible answer is highlighted by von Hippel and von Krogh (2016) with the emergence of the *Need-Solution Pairs* theory. The next part is dedicated to explain this phenomenon.

2.2. Need solutions pairs theory (von Hippel & von Krogh 2016)

As observed in our previous review, problem-solving process literature assumes that formulation of a problem generally precedes the search for solutions. One of the main foundations of need solutions pairs (NSP) theory is to build at the opposite of these assumptions. First, considering the fact that a problem evolves through formulation and re-formulation before reaching optimal formulation (e.g. Kurup et al. 2011), the authors argue that problem solving consists of making a link between a specific point on a need and a specific point on a solution (Figure 15). Second, the authors propose that "*it is conceptually useful to think of a pool of need-related information as the contents of a need landscape that, along with the contents of a solution landscape, are drawn upon for problem formulation and solving*".

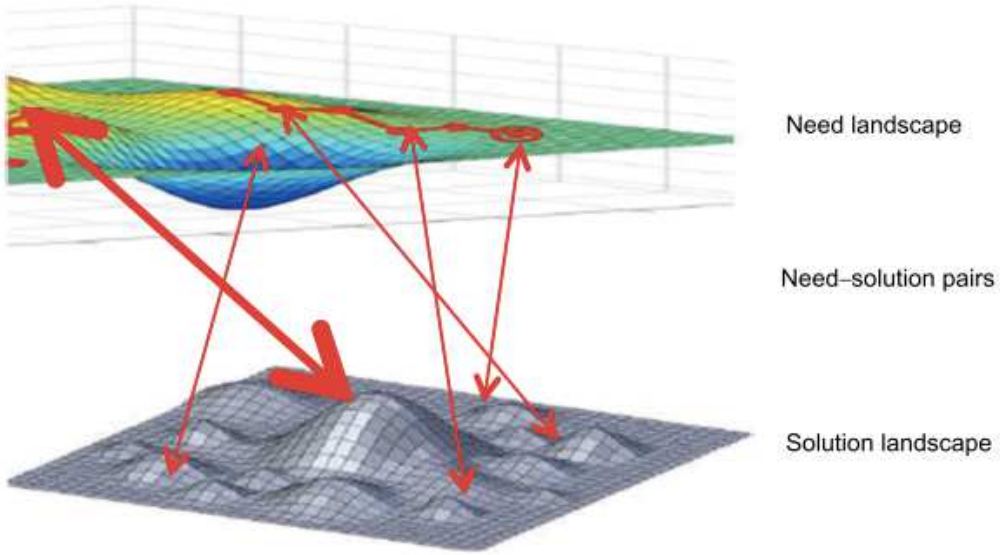


Figure 15: Need and solution landscaped connected by Need-Solution Pairs (von Hippel & von Krogh 2016)

In other words, the authors explain that instead of formulating a single fixed problem, this "new view" of solving a problem, allows to extend the search of solutions into reach

landscape with a plurality of potential solutions. And more important, need and solutions landscapes thus appear simultaneously. Indeed, the authors propose that "a need solutions pairs is viable if the benefit from a solution is equal or higher than the cost of providing solutions. Actually, the value of "reach landscapes" allows converting a single continuous activity (as proposed by traditional practices) into the search a wide range of available solutions. This phenomenon thus increases chances to find solutions by involving a problem statement, treated as temporary, rather than a fixed goal. Scanning all possibilities in a given environment, and then, testing one's need and solution landscapes, comes back to *not* formulate a problem prior to search. In this case, problem formulation comes only after discovery of need solution pairs (von Hippel and von Krogh 2016).

The author explains that this phenomenon is particularly suitable when firms rely on external search of solutions, due to the richness of external landscapes, such as using ideation platform, where many solutions can emerge (Jeppensen & Lakhani 2010) from knowledge and expertise diversity. As evocated in the previous part, several empirical research demonstrated the impact of outsourcing a problem on solutions effectiveness. For example, (Becker et al. 2005) found that the use of external resources lower cost and enables testing a higher number of alternatives. The authors then observed that a higher speed of testing allows testing a higher number of alternatives in the same period, and thus increase likelihood to catch innovative solutions.

Finally, von Krogh and von Hippel (2016) suggest several circumstances in which need solution pairs search could be applicable. As induced by crowdsourcing context, interactions and exchange within participants enlarge the solutions landscape. In addition, by intensifying interactions among users and developers, the software industry could be potential fields to deeper developing NSP method. In other words, the authors acknowledge that each context that aggregates these operating principles "where the emphasis is on frequent an intense interactions" could fit with NSP methods to improve search of solutions.

Although von Hippel and von Krogh suggest possible applications of the NSP method, they ask for exploring conditions for effective Need–Solution Pair Search. Due to the novelty of this phenomenon, either theoretical or practical background did not already investigate this method to solve managerial problems.

3. Challenges for Research

External problem-solving perspective has been recognized as a salient source of value creation and innovation that organizations can access (e.g. Lakhani et al. 2007; Jeppensen & Lakhani 2010). This perspective argues that firms create value as they formulate, identify and solve problems (Felin & Zenger 2015; Nickerson & Zenger 2004).

First, when organizations decide to outsource the problem, they engage in problem formulation (PF), which converts the internal problem into external issue to be solved. Thus, when a problem is well defined, organizations work on formulating and reformulating the problem until they reach the most effective formulation for the crowd. However, not fully defined problem, in turn, often leads to problem formulation limitations. Ill-structured problems, for example, are difficult to convert into well-structured problems because they can affect problem solving process by transmitting inaccurate or incomplete information to problem solvers (Simon 1973; von Hippel & Tyre 1995; von Hippel & von Krogh, 2016). These challenges formulation is thus crucial as it should directly impact the overall solving process and chances for firms to find valuable solution.

Second, we presented in axe 3 a possible answer to this challenge relying on *not* formulate the problem. This assumption comes from a recent emerging theory – Need Solution pairs – which advocates that in informal problem solving process, a need and a solution are often discovered together and the discovery of a viable need-solution pairs (NSP) may have advantages over problem solving traditional methods, and can provide more innovative solutions under certain circumstances (von Hippel & von Krogh 2016).

Third, when organizations search for external solution, they must concentrate effort on searching for value capture to gain competitive advantage. In other words, the search for solutions is supplanted by the search for the *optimal* solution. Recent theoretical research demonstrated the difficulties for organizations to **create** and **capture** value when externally solve problems. For example, Felin & Zenger (2015) explain that uniqueness is the discriminator between creating value that flows solely to customers and creating value that is at least partially captured by the focal firm. Value creation for the focal firm, therefore demands for firms to discover or solve unique problems—problems or solutions unseen by or inaccessible to others.

However, while recent research acknowledge the value of crowdsourcing (eg. Afuah & Tucci 2012) for solving problem, there is still limited research on how to capture value from the selected solutions (Bloodgood 2013).

To conclude, we observed that existing literature has widely explored how to overcome problem formulation issues (e.g. Lyles & Mitroff 1980; Lopez-Vega et al. 2016; von Hippel & von Krogh 2003) and well-studied how external resources can improve the overall problem solving process (Terwiesch & Xu 2008; Lakhani et al. 2007; Brabham 2008). However, little research to date investigated the notion of value capture when outsourcing the search of solutions. Yet, the question today is not just that a problems needs to be solved; but it is also important for firms to understand how the problem should be solved (Bloodgood 2013). In other words, well-established knowledge on the importance of value capture and value creation (e.g. Lepak et al. 2007) needs to be transpose into crowdsourcing issues, in order to help firms to answer the question of **how to optimize the search for innovative solutions in crowdsourcing context?**

We thus need to understand (1) how external problem solving process could lead to capture value of solutions and (2) is the NSP method exploitable to help firms to answer this issue. Hence, our study 3 proposes to answer these issues by investigating the following research questions: How and why organizations have to formulate or not the problem in order to grasp external value?

Study 3. Formulate or not formulate: Solving Problems with a Dynamic Capabilities Perspective

1. Responses to Challenges

Recall that the aim of our research is to answer the question of what are the determinants of user innovation. We previously observed that firms have the possibilities to outsource the search for solutions and rely on external actors, such as lead users, to potentially discover innovative ideas or solutions. Additionally, IT tools, such as ideation platform, allow developing a relevant context by increasing interactions and knowledge sharing. However, we also acknowledged some limitations. Specifically, we highlighted that to maximize the idea generation process firms need to focus on the nature of the specific problem and how users are asked to contribute (Afuah & Tucci 2012). In other words, the methods of formulating the problem seem to be a crucial step before engaging idea generation process. This issue is directly related with our purpose in axe 3 and the need to optimize the search of value creation and then value capture in crowdsourcing context (Peppard et al. 2011)

As a result, we focused on better understand the overall problem-solving process. Our review revealed that problem solving process is a critical purpose and arises several issues. First, past research demonstrated that problem formulation is often associated with a lack of accuracy, as successive reformulations tend to transmit inaccurate or incomplete information to problem solvers (e.g. Simon 1973).

Second, while von Hippel and von Krogh (2016) proposes a new way to solve problem in eliminating the formulation steps, little is known on how this method could be applicable in practice.

As a result, it appears that organizations have to choose between two options when outsourcing the problem: (1) rely on problem formulation (PF) approach following “classical” problem-solving process or (2) search for need-solutions pairs (NSP) discovery to find solutions. Nevertheless, this important question for both academics and organizations is still pending answers: How and why organizations have to formulate the problem, or not?

In this paper, we propose to theoretically investigate this question. Rather than adjudicate between this two options, we propose that, these two alternatives are not opposite, but rather complement one another. We approach the problem by proposing that the either ways if an organization begin by the search using a PF or a NSP approach, the output of the first

(formulated or not formulated) will nourish the input (solution or formulated problem) of the other and the process will continue to iterate ill it reach the most optimized solution.

To support our argumentation, we first focus on the idea as unit of analyze. We approach the problem by offering a conceptual process framework built on evolutionary theory (Staw 1990) in order to explain how variations among individuals make the process iterative, between the search and solutions landscapes, and thus between NSP and PF.
Second, while we aim to demonstrate complementarity and iteration between NSP and PF, at the heart of our argument lies a novel appreciation of how to capture value in searching for not only external solutions, but also the optimal one (Bloodgood 2013). We consider that the optimized solution entail a dynamic transition during the elaboration phase in order to optimize the final idea. Therefore, we integrate the dynamic capabilities perspectives in order to explain how to catch most valuable solutions through the problem solving process. The next part is dedicated to deeper explain methodology to build our theoretical reasoning.

2. Research Design

2.1. Literature review

Following Webster & Watson (2002) we framed our literature review with the model of problem-solving process including three phases: (1) problem identification, (2) problem formulation and (3) problem finding. As our objective was to explore problem-solving process in the specific context of crowdsourcing, articles were selected in EBSCO and ABI inform database of eight journals (AMR, JOMresearch, AMJ, JPIM, Research Policy, MISQ, OrgScience and JMIS). In addition, we built our literature review on the aim to (1) identify challenges related to problem formulation and factors that influence problem-solving process creativity, and (2) evaluate the process whereby value is created and captured during problem soling process, as suggested by von Hippel and von Krogh (2016) and Bloodgood (2013). As a result, we targeted the full text of the articles from these journals based on the following keyword search: "problem solving" AND “crowdsourcing” AND (methodology or method) AND "process creativity" OR "innovative solution" AND “value OR capture”. Following the initial search, each article abstract was scrutinized to ensure that the presence of the keywords was not cursory and that our inclusion/ exclusion criteria were satisfied (Webster & Watson 2002). Extract of the final list is presented in table 5 – axe 3.
As previously explained, the review revealed that first; firms increase likelihood to develop

innovation when outsourcing the search for solution. Second, we identified issues related to problem formulation and third, difficulties for firms to optimize the search of the most innovative solutions.

In addition, we also included the von Hippel and von Krogh recent paper (2016). Indeed, as their study was designed to answer gaps identified in existing literature on problem solving, it was obvious to build our reasoning on the need solutions pairs theory.

At the end, we identified two specific gaps. First, there is a need for theoretically explain how NSP and PF are not opposite but rather two complementary processes. Second, we need to understand how firms can capture value using PF and NSP.

Our next step was to build a theoretical concept to answer these issues.

2.2. Theory building

2.2.1. *Experiment*

To illustrate how it may be done, we consider two examples of ideation contest. These include two open call challenges on tactile tablet product, using an idea generation platform, where the first one will follow the problem formulation approach and the second one will be formulated in a reverse manner, with the willingness to not formulate the problem, but rather to invite the crowd to reflect largely. Through these examples, our objective is conceptual clarity rather than empirical validation. We use these examples to explain our argument more concretely, and not to offer evidence from them.

Hence we observed that if the company decides to use the problem formulation approach, participants are confronted with precise instructions to solve a problem. Ideas among participants are emerging and posted on the platform following the instructions. When participants see ideas of others, they can comment, like, vote, and even improve ideas of each other. These interactions between participants make the ideas progress and develop. This variation phenomenon is the concrete representation of idea elaboration phase, in a crowdsourcing context. On the other side, if a company follows the NSP approach to introduce a problem to the crowd, participants do not have to follow any instruction and are free to post multitude of ideas. However, when ideas emerge, interactions among participants (comments, votes and likes) encourage individuals to self-formulate the problem in order to obtain necessary information on others ideas and reformulate them. Consequently, the problem-solving process through an ideation platform follows an iterative idea evolution

process that build on the ideas variation among participants that go from problem formulation to need solution pair and vice versa.

2.2.2. *Theoretical insights*

In order to the identified process related to ideation context, we argue that we need to focus on the idea as unit of analysis. As a result, we build on a Darwinian view of idea evolution. The idea evolution process refers to five steps:

- Preparation: immersion in a set of problematic issues
- Incubation: unconsciously processes information
- Insight: new ideas emerge
- Evaluation: judge the idea
- **Elaboration: individual pursues the new idea by transforming, developing and refining it**

We specifically focus on the last step, elaboration, since it might explain how the idea can follow an iterative process between individual. Indeed, several research built on this phenomenon to answer managerial issues and explain idea creativity (e.g. Mainemelis 2010; Amabile et al. 2005; Simonton 1999). Amabile et al. (2005) explain that once the creator has selected an idea, developed, and communicated, there is often a second selection process by relevant individuals in a social group or intellectual community. As a result, we argue that problem-solving process through an ideation platform follows an iterative idea evolution process that build on the ideas variation among participants that go from problem formulation to need solution pair and vice versa. Thus, in a crowdsourcing platform context, PF and NSP process are not in competition but they are complementary.

Having explained this iteration, we need to explore how integration and combination of both approaches could optimize problem-solving process in such context and help finding the best solution.

In order to explain the process of value capture in our specific context, we based our reasoning on Teece's (2007) view of dynamic capabilities. Indeed, our prior review allowed us to identify several research that developed a capability-based framework of open innovation, demonstrating that ‘knowledge management capacity’ is a dynamic capability, which reconfigures and realigns the firm’s knowledge capacities (Ridder 2011; Lin et al. 2016). As a result, we argue that idea elaboration process has to be couple with a DCs

approach in order to optimize the search of optimal solution in problem-solving process and we describe the different process steps (Figure 16).

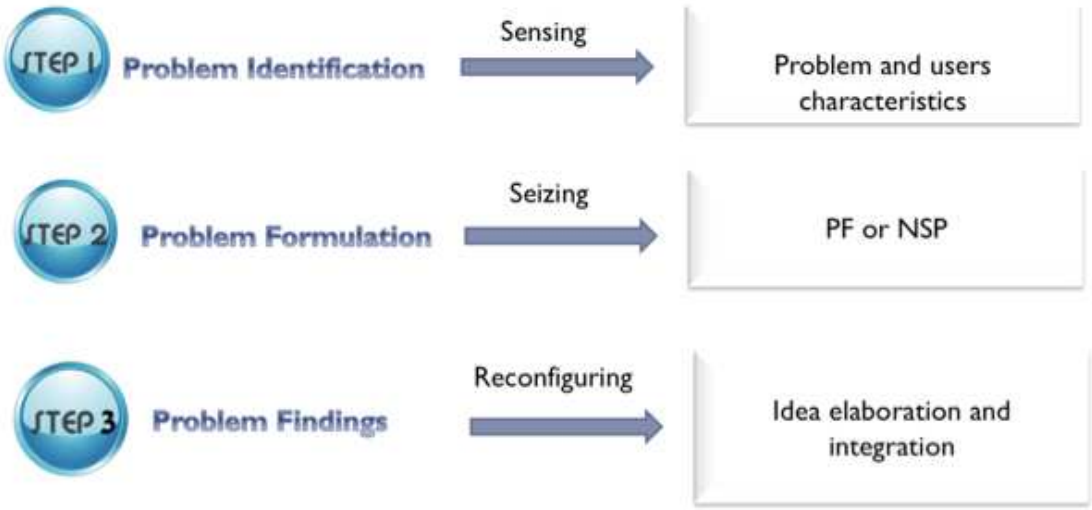


Figure 16: Dynamic view of problem solving process

3. Results

Finally, we propose in this paper a conceptual model (Figure 17) explaining the iterative process between PF and NSP. We also introduced a dynamic capability perspective of problem solving process. This model allows to determine in which conditions a firm might formulate or not a problem. These conditions have been established following our literature review. We propose that before choosing how to introduce a problem to the crowd, firms should determine the characteristics of:

- the desired solution (Spradlin 2012; von Hippel & von Krogh 2016)
- knowledge required to answer the problem (Haas & Criscuolo 2015)

In other words, firms have to *sense opportuniti*es depending on these characteristics, before *seizing opportunities* of formulating or not. Only after comes the *reconfiguration* of resources during the idea elaboration phase, enabling firms to optimize final solution.

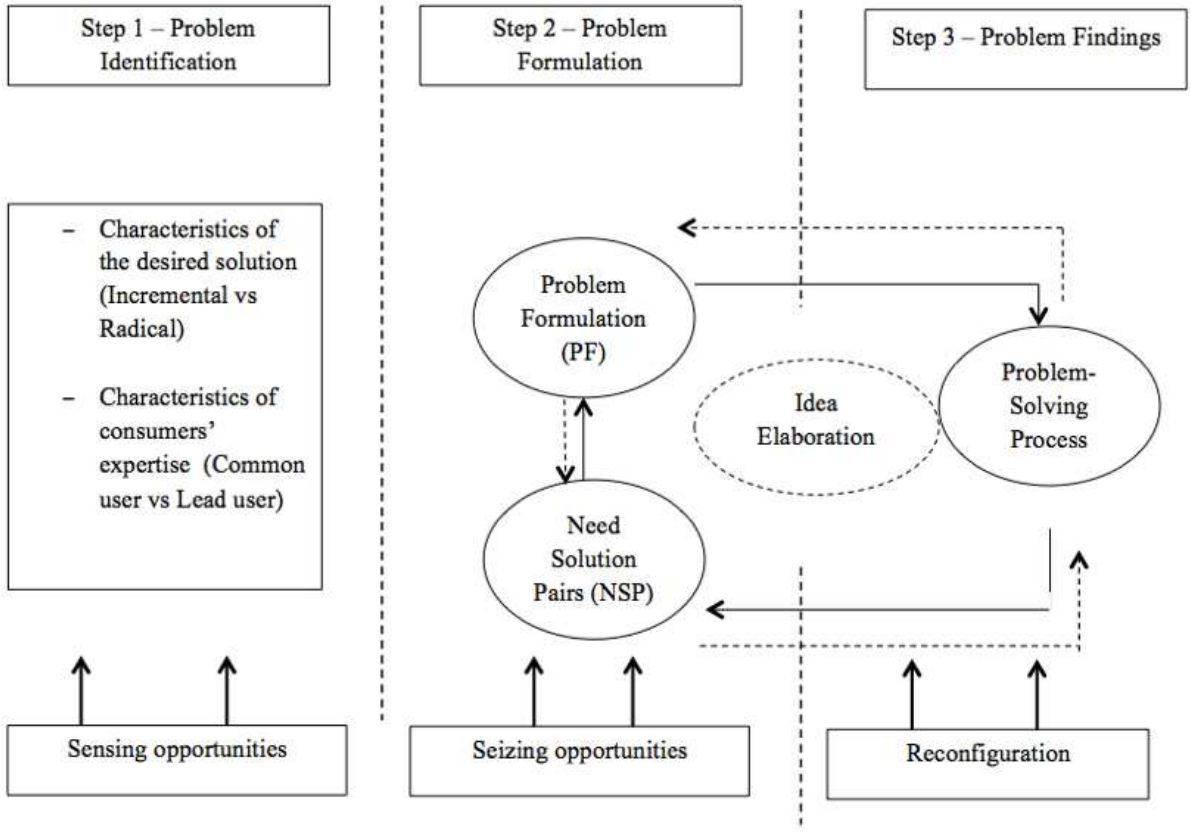


Figure 17: Problem-solving process: a dynamic capability based model of idea evolution

General Discussion and Conclusion

Our dissertation set out to investigate user innovation in digital environment through the following problematic: **what are the determinants of user innovation?** To answer this question, we decided to adopt a complementary approach rather than building on a specific founding theory. This choice is driven by several reasons.

First, the open innovation paradigm includes many concepts that jointly evolve and operate. For example, when firms decide to adopt an open approach to gather innovation, they might include virtual teams, cultural openness, technological modularization and public/private collaboration at the same time (West & Gallagher 2006). This multi-faceted approach makes the search for external knowledge complex and difficult, and points to huge uncertainties that firms have to deal with (Laursen & Salter 2006).

Second, the open innovation paradigm is more than the use of external sources of innovations such as customers, competitors or universities (e.g. von Hippel 1986). Instead, firms should be aware of the change in the use, management and practices that open approaches imply. In other words, exploring and exploiting innovation opportunities (Cohen & Levinthal 1990) is a process that follows multiple channels, which need to be highlighted.

For these reasons, we decided to answer our problematic through the analysis different levels: actors, tools and methods as determinants of user innovation.

We first focused on the actors. In the context of open innovation, companies co-create with actors, who are in this specific context, external from the focal organization. For example, rather than ask its own design group to design the next car model, an automobile manufacturer could crowdsource the task in the form of an open call to the world (Afuah & Tucci 2012). It thus offers many opportunities for firms to interact with an unimaginable amount of different people. We thus proposed to deeper investigate characteristics and roles of these actors through the following research question: **who are the external actors who enhance innovative ideas?**

We then investigated the tools as mean to co-create. Indeed, past research previously highlighted that the higher the level of interactions and exchanges are between firms and external sources, the higher the level of output innovativess is (e.g. (Jang & Chung 2015; Terwiesch & Xu 2008). Thus, we suggested to study deeper the nature of these interactions enabled by IT tools by exploring the following research question: **what are the best tools to gather these ideas?**

Finally, we focused on the methods. This last part referred to the question on how to search, by exploring different possibilities to turn a problem towards the crowd in order to optimize the search of solutions. Specifically, we investigated the overall problem-solving process following several methods (i.e. formulate or not to formulate a problem), in order to answer the following research question: **which are the best methods to collect innovative inputs?**

In this section, we propose to answer these three research questions by pointing out our main contributions across our three studies. We will also present theoretical and managerial implications for each study and then discuss limitations. Finally, we will suggest avenues for future research.

AXE 1 – DISCUSSION, IMPLICATIONS AND LIMITS

As noted in introduction, we build on user innovation theories in order to answer the questions related to actors as a source of innovations. More specifically, past research in user innovation highlighted one category of users labeled as lead user (von Hippel 1986). Prior research suggest that due to their special characteristics, lead users generate better ideas than the average consumers (e.g. Luthje 2004). As we aimed to specifically understand how innovative outputs could be created, we thus focused on these specific types of users to explore the question. In addition, past research mainly focus on studying lead user offline. Yet, our aim to explore user innovation in virtual environment leads us to approach the research question by conducting an analysis of lead users characteristics in an online context based on an ideation platform experiments.

In article 1, we identified and constructed a typology of lead users characteristics required to better understand their profile in the specific context of open-challenge. We conceptualized the specific attributes for identifying online lead users and developed propositions to contribute to the identification process of lead users via crowdsourcing tools such as an online ideation platform.

The findings are quite counterintuitive from the perspective of classical lead user literature. Indeed, while previous studies demonstrate that lead users are characterized by a strong knowledge on very specific products (Morrison et al. 2004; Hienerth et al. 2007), we found that during ideation challenge a specific knowledge is not required to propose innovative ideas. Further, the in-depth interviews with screened potential lead users allowed us to

identify that their need for innovation does not come from an expected need (Urban & von Hippel 1988; Hienerth et al. 2014). Our results interestingly revealed that in the context of ideation, innovativeness of lead users' ideas comes from intrinsic motivations related to challenges rather than from the need to answer expected benefits. We found that intrinsic motivations, such as the willingness to show other participants that they have better ideas or better knowledge, as well as extrinsic motivations such as prizes for the winner solutions, are substitutes to replace offline lead users characteristics. This view is consistent with motivations theories in the context of ideation challenges. Several research acknowledged that applied to ideas competitions, the potential to win a prize may act as an external incentive. Further, personal fulfillment or having fun when developing a new idea could similarly intrinsically motivate participants (Leimeister et al. 2009).

From a theoretical perspective, we first contributed to address the gap of online lead users detection, by building a typology of their characteristics. We bring out some differences with offline studies regarding three main attributes: ahead of trend, consumer knowledge and need for innovation. By studying lead users during idea competition, our study has implications for research on user innovation. Prior user innovation research has focused separately on lead users and crowdsourcing research literature. Our motivation for exploring the sources of innovation during idea competition highlights the interplay of lead users with their characteristics in this context. Lead user research has so far concentrated on offline characteristics. The findings complement this research by extending knowledge on lead user profile and the nature of these specific consumers in another context.

Second, lead user research has mainly relied on the lead user methods to identify lead users, using screening or pyramiding techniques (e.g. von Hippel et al. 2009), but also recognized that these methods are often costly and time consuming. Our study proposes that idea competitions can represent an interesting approach to identify and integrate leading-edge users into NPD projects, that is relevant for innovation management (Luthje & Herstatt 2004). While research on the antecedents of lead user innovations provides the theoretical basis for the identification of promising users (Morrison et al. 2004), our study extends this knowledge by completing the understanding of lead user profile and determines indicators that could allow for their identification.

From a managerial perspective, our finding can help firms to understand what does really influence the generation of novel ideas and most important, how to recognize promising users. Indeed, in idea competition context, lead users are not necessary experts on specific product or brand. Thus, firms should integrate users from far analogous markets in terms of market

characteristics rather than focusing on very specific profiles who are more difficult to identify and integrate (Hienerth et al. 2007). Doing so, they can really make cooperation with lead users and harness creativity for example in the form of a platform for the generation of innovative ideas.

However, we acknowledged the limitations of our study that highlight the need for further research. First, we would like here to discuss the fact that the challenge brief of our study asked participants to "invent the next generation of tablet", which is a relatively open assignment with little guidance. However, the innovativeness of users' ideas substantially depends on the nature of the specific problem and how users are asked to contribute (Afuah & Tucci 2012). Therefore, the way of a problem is formulated to the crowd should have a non-neglected impact on users' behavior. Future research might go deeper on understanding how to formulate the problem, depending on the desired solutions and types of participants (Felin & Zenger 2015), in order to increase the chances to maximize the idea generation process. This limit constitutes one of our motivations to go on these suggestions and led us to examine the methods to improve innovation process. This aspect will be address in article 3 discussion. Second, while we found that virtual environment represents a relevant context to identify and grasp innovative ideas, past research on lead user recognized that some lead users cannot translate their assessment of unsatisfied needs to an assessment of a new product's success in the market place (Spann et al. 2009). As a result, the concepts of emergent customer (Hoffman et al., 2010) and creative customer (Berthon et al., 2007) have been consequently proposed in the literature to enlarge the scope and the profile of customers' innovativeness. However, these three streams of literature developed around the concept of user innovativeness, focus neither on the personality characteristics and traits of these customers nor on the creative cognitive process required to develop and enhance their participation to the NPD process. Considering that individual creativity could positively impact the performance of their creative output (Zhou & Oldham 2001), future research should explore personality traits and user creativity as antecedent of innovative idea generation. Aware of this limitation, we launched a novel experiment in the Minder Platform in order to evaluate the link between personality traits of common users and idea performance, with the goal to better understand the emergence of creative behavior in this specific context. Considering the main individual determinants of creative performance – creative skills, domain-related expertise, and task motivation (Amabile et al. 1996), we applied this model to a group of electronic table users to evaluate the effect of these components on the performance of the

generated ideas. First results of this study seem to indicate that customer's creativity, expertise and motivation have a positive impact on the performance of their creativity output. While this study is still in progress, it should constitute an interesting basis to develop the present research. This study should extend our understanding of the actors as a source of innovation by exploring how common users could represent interesting value for firms to gather innovation. First results are presented in the appendices (Article 4).

AXE 2 – DISCUSSION, IMPLICATIONS AND LIMITS

"Sophisticating online crowdsourcing platform" (Boudreau & Lakhani 2013) are recognized to support and manage distributed user innovation (Bayus 2013; Huang et al. 2014). As the aim of this research is to understand determinants of users innovation, we concentrated on exploring how crowdsourcing tools enable firms to collect promising ideas.

Consequently, we focused on two different tools i.e. ideation platform and Open Source Software as means to co-create.

We saw before that article 1 allowed us to build an online typology of lead user characteristics. We also explored through this study how an ideation platform can represent an efficient tool to gather innovative ideas by deeper focusing on the platform and challenge designs.

From a theoretical perspective, our study reveals that online ideation platforms offer a particular context suited to identify lead users. As it should be useful for firms to explore the ways using toolkits such as ideation platforms to improve identification of promising ideas (Nambisan & Baron 2009), we suggest that ideation platforms allow improving idea selection process, by involving participants in each process steps. Indeed, participants seem to be more able to take part in decisions, when they feel fully implicated in the overall process through votes and comments (Leimeister et al. 2009), and most important when they receive incentives for their involvement. Thus, while firms often have to deal with too many ideas, involve and motivate the crowd with incentives into tasks such as filtering, voting, idea screening or idea ranking seems to reduce time and cost of selection process. So far, past research on crowdsourcing platform mainly focused on idea performance (e.g. Lilien et al. 2002), users participation (e.g. Bagozzi & Dholakia 2006) or characteristics of communities (e.g. von Hippel 2001). Our study extends crowdsourcing literature by providing interesting insights on selection process during idea competition. The design of the platform and the

challenge allow to involve participants in early stages with vote and comment activities, which considerably improves idea selection process.

Managerial implications of this article are that organizations should consider to create compelling virtual experience to motivate and inspire participants to generate creative ideas (Garcia Martinez 2015). Still, companies often demonstrate some resistances to involve crowds, because managers do not clearly understand what kinds of problems the crowd can really resolve better (Boudreau & Lakhani 2010). In the context of crowd contests, a company could interestingly transform a problem into attractive challenges that create valuable conditions to gather innovation.

Open innovation literature also widely focused on open source software as it highlights many ways for firms to enhance their competitive advantage by using the ideas of user (West & Gallagher 2006). As a result, Article 2 explored open source software as a mean to innovate. Based on our data analysis, we identified that OSS popularity is positively influenced by user-developer interaction, market potential and the development stage during OSS development. Nevertheless, we found some differences with existing literature.

First, while we found that extensive information exchange (information flow) among users and developers is optimal for knowledge sharing and, is associated with greater OSS popularity, the lack of significance for the effect of bug-related activities on OSS popularity is controversial with previous research. Indeed, our results interestingly reveal that in such context, bug-related activities do not have any impact on OSS popularity and do not constitute a valuable measure for project popularity in the case of less well-kwon projects.

Second, we demonstrated that the effects of user-developer interactions and market potential on OSS popularity change as projects move through different development stages. While previous research only investigated development stage as a control variables, we empirically show that development stage plays an important role in determining project popularity, especially for more advanced projects.

From a theoretical perspective, little research to date has explored OSS performance in the case of less-well known projects. In addition, few studies have used popularity as an output to measure a project performance. Our research advance theoretical knowledge in IS literature by highlighting that market potential and development stage represent valuable measure to evaluate the level of interest for OSS projects. More specifically, we demonstrated that depending on the project evolution, an extensive user community improves perceptions of a project because of the resulting positive word of mouth (Van den Bulte & Lilien 2001) and

generally increases the potential and viability of the project. Furthermore, the level of information flow was shown to have a significant impact on OSS popularity, supporting our arguments that such interactions between users and developers increases users' interest in a project and thus the number of downloads. In other words, the level of communication inside virtual communities is a more valuable measure for OSS popularity than the numbers of developers involved in the community in the specific case of less mature project consistently with the user innovation literature (Schreier et al. 2012; Raasch et al. 2013) .
Concerning implications for practice, our study suggests that beyond the number of users or developers, the activities of these actors—that is, the level of information flow among users and developers—is directly related to OSS popularity. Firms should thus be aware that simply attracting developers may not ensure project success (Stewart & Gosain, 2006), and managers should focus on developing quality interactions among members in order to foster OSS popularity. In addition, the number of pages viewed represents an important concern for firms, as it signals the general level of interest for a project. This measure of market potential for an OSS project should thus represent a valuable indicator of OSS popularity that firms may take into account during OSS development or decision-making.

However, this study also presents some limitations. We would like here to highlight the fact that our model is not appropriate for determining the influence of individual factors on OSS popularity. Regarding IS stream of literature, numerous studies have relied on individual factors that lead to the emergence of projects leaders within an OSS community and have linked these skills to OSS success (e.g., Lerner & Tirole, 2002; Giuri et al., 2008). User innovation literature also argues that individual creativity is induced by environmental factors (Nambisan & Baron 2009; Sirmon et al. 2007), and explains innovative outputs by investigating emergence of creative behavior in such context (Toubia 2006; Sonenshein 2014). It would be useful for future research to apply and transpose these individual factors to our model in order to increase our understanding on how IT tools increase the emergence of creative outputs. Consequently, we started to investigate this limit by building on e-leadership theory (e.g. Avolio et al. 2001) and tool enjoyment as antecedent of user creativity. This paper is still at an early stage of development, but first results support the conceptual idea of this study that internal motivation and tool support influence positively user enjoyment and finally impact transformational leadership and creativity. This study could allow us to deeper investigate IT tool, such as OSS or ideation platform as mean to co-create, and specifically

how the design of IT tool could generate creative behavior from participants. First results of this study are presented in the appendices (Article 5).

AXE 3 – DISCUSSION, IMPLICATIONS AND LIMITS

Axe 3 of our research comes as a global and comprehensive view of user innovation determinants, as we aimed to study the overall mechanisms of the search for external innovation. We thus focused on investigating the methods, by which an organization could use the crowd to gather innovation. To do so, we explored problem-solving process and specifically, the optimized ways of addressing a problem to external solver.

Consequently, article 3 addressed the following research question: how and why organizations have to formulate the problem, or not? Through this question, we also address the need to understand how firms can obtain not only innovative solutions from the crowd, but also capture unique value by optimizing the idea generation process.

We thus proposed a conceptual model of the problem solving process by introducing a dynamic capabilities perspective on idea evolution process as a valuable mean to create and capture value from crowdsourcing (Bloodgood 2013). We build on two fundamental theories in problem-solving literature: problem formulation (PF) theories (e.g. Simon 1990) and a more recent view of need solution pairs (NSP) theory (von Krogh and von Hippel 2016).

From a theoretical perspective, we add contributions to the emergent theory of need solution pairs (von Hippel & von Krogh 2016). First, we enlighten the functioning of NSP method by integrating it within a crowdsourcing framework. This specific framework allows identifying first understanding of how NSP can suit with practical environments.

Second, we conceptualize the search for solution using NSP and demonstrate that PF and NSP methods should be complementary rather than opposite following an iterative process. This iteration is suitable with theories on creativity (Mainemelis 2010) and supports idea evolution and resources reconfiguration through challenge participants, allowing to increase idea quality until reaching the optimal one. This model extends innovation literature and helps to understand the idea creation phase (Dahl and Moreau, 2002). Following the idea that this "iterative irrational creative process" can explains innovation, recent research in innovation found that artistic creativity and organizational innovation should share a common problem-solving process as "it involves paired constraints that limit and direct search for a solution path. One of each pair identifies something to be precluded; the other specifies its substitute"

(Stokes 2014). Our study extends this view by highlighting a better understanding of iterative creative process applied to the search for innovation.

From a managerial perspective, our results could help companies in several ways. First, concerning crowdsourcing knowledge and insights, scholars mainly focused on explaining the conditions in which a firm should rely on external knowledge (e.g. Afuah & Tucci 2012). Second, concerning problem solving literature in an open context, academics mostly struggled on explaining the advantages of outsourcing the search for solutions (e.g. Füller et al. 2009; Terwiesch & Xu 2008; Prügl & Schreier 2006) and provide relevant insights for open innovation-related issues (Chesbrough 2011). Hence, past research widely investigated the questions of **when** and **why** to crowdsource a problem.

In this paper, we propose to advance knowledge on the question of **how** to crowdsource a problem. In other words, we help companies to identify the methods (i.e. PF and NSP) whereby they should introduce a problem to the crowd, and identify specific conditions for this decision-making process. Furthermore, we propose here to introduce the idea of capturing unique value from external idea generation process (Bloodgood 2013). Indeed, we develop novel insights on how to optimize this process and reach not only innovative solutions but the optimal ones. Our results could help companies to increase likelihood for leveraging innovation, and thus to propose unique products and develop competitive differentiation through innovations (Peppard et al. 2011).

The present study has also some limitations that we need to highlight. First, given the complexity of the relationships between PF and NSP and the lack of literature background, this paper takes a first approach, which argues for the iterative process between these two methods. We thus acknowledge that our study provides only a first-step toward the understanding of process to optimize the search for solutions and capture unique value from external sources. Second, as we aim here to develop a theoretical paper, our study is based on conceptual reasoning and knowledge. While we acknowledge that outcomes of PF and NSP can be linked in more complex ways into practical environments, future research can look at how these two methods can be related in practice, and empirically test the efficiency of formulate or not the problem. To answer these limitations, we recently collected data from two specific open call experiments. The first one follows the problem formulation approach in precisely formulating the problem to the crowd: How to improve tactile tablet. To answer the challenge, you have to reflect on the following criteria: Memory, Weight, Features, Battery, Connectivity, Touch Screen and Design. Thus, participants have to follow precise

instructions. The second is formulated in a reverse manner, with the willingness to not formulate the problem, but rather to invite the crowd to reflect largely among strong interactions within participants. Thus, we asked participant to "Invent the next tablet generation, as proposed by NSP theory". Currently, we are analyzing data to compare ideas innovativeness when formulate or not the problem. This paper is co-developed with Professor von Krogh (ETH Zürich). We expect that this study will allow building empirical basis to extend need solution pairs theory, and provide useful insights regarding the methods for outsourcing the innovation process.

To conclude, this doctoral research addresses the fundamental issue of the user innovation determinants in the innovation process for the generation of new ideas in digital environment. This research builds on different literature streams: Innovation, Information Systems and Problem-Solving literature. Instead of studying these research streams independently, we aimed carefully to understand their link to the production of creative behavior. The interrelations between these three levels come from the idea that underlying mechanisms of open innovation aggregate different forms and manifestations at several levels of individuals, organizations and environment (Felin and Zenger 2014). Consistent with this view, our findings show a clear need to link actors, tools and methods in order to improve likelihood for firms to gather optimal solutions from external sources. Specifically, our research shows that the generation of novel and useful ideas from individuals (the actors) is widely influenced by the environment (IT tools) and the ways of addressing a problem (the methods). This perspective offers an integrative framework that seems to be particularly useful for clarifying open innovation paradigm complexity (Chesbrough 2004). Using this perspective, this research contributes to advance knowledge on these three research streams as suggested in the discussion section.

In particular, this dissertation improves knowledge on user innovation theories, by deeper exploring *lead users* and provides a typology of their profile in an online context.

This work also adds knowledge on crowdsourcing literature by investigating how digital environments could enable idea generation, namely the design of IT tools, such as *ideation platforms* and *open source software*.

Finally, this research enables to identify most promising methods to turn an internal problem into attractive challenges for the crowd. Specifically, this study contributes to the problem-solving literature, by proposing a conceptual model on when to *formulate problem or not*,

depending on several conditions. This model also provides interesting insights concerning the under explored topic of how organizations can capture value from crowdsourcing (Bloodgood 2013; Lepak et al. 2007), using a dynamic capability perspective of idea evolution.

However, this research is not without limitations that have been highlighted in the discussion section. In particular, while this research mainly focused on external factors, there is a need to better explore individual factors in the digital environment as antecedents of creativity. Because creativity is necessary but not sufficient to develop innovation (Carayannis & Gonzales 2003), this perspective could allow for a better understanding of how creative behavior in such environment could lead to the production of innovative ideas, and have an impact on the performance of organizations.

This perspective also demonstrates a need to pursue investigations of innovation antecedents and implications, across the multiple possibilities to approach and understand the open innovation paradigm.

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Article 1

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Identifying Lead Users Online: A study of a co-creation platform

Nassim Belbaly* and Clémence Cheruy*

*Montpellier Business School, 2300 avenue des Moulins 34185 Montpellier Cedex 4 France

Abstract

While much research has emphasized including customers in New Product Development process, it has been proved that companies and customers are now working together. Additional studies worked on improving this co-creation movement and focused on specific customers labeled as Lead users. Moreover, advance in technology fosters online co-creation through idea generation toolkits such as ideation platform. As opposed to previous studies in which lead users were selected offline by firms and then used in new product development processes, the paper employs an online crowdsourcing platform to locate lead users and address the following question: which characteristics distinguish online lead users who are involved in a co-creation platform, and how to detect them? Through a case study of a co-creation contest, the authors explored the detailed nature of lead users and developed a typology of online lead user characteristics using rich qualitative data derived from detected online lead user characteristics (Ahead of trend, consumer knowledge, and expected benefits). The major findings of this study are that having all these attributes is not strictly necessary to be identified as a lead user in an online ideation contest. These findings allowed the authors to advance the theoretical understanding of what online lead users are and how they can be identified by conceptualizing their characteristics and attributes.

Introduction

The many studies investigating how firms create new products and services by collaborating with customers have developed the concept of the "lead user" (Hienerth et al., 2007; Lilien et al., 2002; Urban and Von Hippel 1988, 2005; Von Hippel, 1986). Interconnectivity and crowdsourcing enable customer collaboration by integrating online lead users into new product development processes that reduce the high failure rate of new products. This new trend has contributed to the development of the concept of online lead users (Potz and Schreier, 2012; Spann et al., 2009). However, as a theoretical concept, the notion of online lead users remains underdeveloped. Researchers have struggled to define the exact basis of how online lead users differ from offline lead users (e.g., Dahan and Hauser, 2002; Hienerth et al. 2011; Nambisan, 2003). Specifically, there is little empirical research addressing the following questions posed by Potz and Schreier (2012): How can we define and filter out large numbers of anonymous customers to identify lead users on the Internet? Are there methods to identify these lead users? We address these research questions in detail in a case study of a co-creation contest involving the online ideation platform called the Minder platform.

Von Hippel (1986) and Urban and Von Hippel (1988, 2005) provide a key theoretical contribution by defining "lead users of a novel or enhanced product, process or service as those who display two characteristics with respect to it: - Lead users face needs that will be general in a market place, and - Lead users are positioned to benefit significantly by obtaining a solution to those needs".

We further explore those characteristics of lead users noted by Von Hippel (1986) but explore other salient characterizations of lead users, such as those found in Luthje & Herstatt (2004), Schreier & Prugl (2008), Franke & Shah (2003), Jeppesen & Lakhani (2010) and Luthje, (2004), including the following: user experience, product-related knowledge, community, opinion leadership, involvement, technical expertise, dissatisfaction and need for innovation. We elucidate a taxonomical ordering of the characteristics of online lead users – distinguished from those of offline lead users. This taxonomical approach allows us to identify and group together certain characteristics of lead user concepts that are similar to one another and also helps explain how we can identify online lead users and integrate them into new product development processes, as described by Potz and Schreier (2012) and Spann et al. (2009).

We employ user interviews (Hienerth et al. 2011) to examine the differences between the characteristics of offline and online lead users in an online ideation contest (Kristensson et al.

2004). We utilize a case study approach (Yin 2003; Eisenhardt,1989) to study users of an online crowdsourcing platform participating in a contest to generate new ideas for a tablet. During the ideation contest, participants engaged in a concept stage gate process to recreate a realistic setting to identify lead users (Spann et al. 2009). We were able to screen and analyze lead users' behavior on the platform over the course of three months, which resulted in a rich data collection over a relatively short period of time.

We contribute to knowledge regarding lead users in three ways. First, we create an empirically grounded syndissertation of lead user identification that advances the theoretical research agenda originated by Von Hippel (1986) and Spann et al. (2009) and that answers the questions raised by Potz and Schreier (2012) regarding how to identify lead users in general (Hienerth, et al., 2007; Lilien et al., 2002) and online lead users, in particular. Second, we identify three main characteristics of lead users: being "ahead of trend" indicates that the user has the capacity to be both at the forefront of and involved in communities (Franke and Shah, 2003, Franke et al., 2006; Luthje, 2000, 2004; Morrison et al., 2002), having consumer knowledge indicates that the user has product knowledge and the technical capability to make changes (Luthje 2000, 2004; Schreier and Prugl, 2008), and expecting benefits considers the level of consumers' dissatisfaction and their desire for innovation (Luthje, 2004; Von Hippel, 1986). We elaborate these three online lead user characteristics through the iteration between rich case study data (consisting of a combination of survey-based screening and qualitative interviews) and the constructs from the previous literature. We demonstrate that these features form the cornerstone of the three necessary characteristics to detect online lead users, which allows for a more precise identification of such rare subjects during an ideation contest. Finally, based on the characteristics of lead users in an online ideation context, we find that having all these attributes is not strictly necessary to be designated as lead user. For example, we demonstrate that lead users in an online context need not be experts on the product nor have extensive knowledge regarding the product but that knowledge of the product family suffices for a lead user to provide the added value that firms expect.

We proceed as follows. First, we briefly outline the relevant key theoretical debates. We then explain our case-based methodology and present the co-creative context of the Minder platform, including a description of the different aspects of this platform and the online challenge that we initiated for this case study. Next, we present our empirical findings regarding the characteristics of online lead users that emerged from the data. Most of the extant theory and its connection with our findings are positioned in the Propositions section

because our methodology is data-driven, and only later do we engage with the literature (see Dixon et al., 2014 and Pratt et al., 2006 for a similar approach). We then discuss the theoretical implications of identifying lead users by integrating the literature into our analysis, and we relate these implications to the context of online co-creation. We conclude by elucidating the implications of our study for both theory and practice.

Theoretical foundations for defining the characteristics of lead user

Howe (2006) explains that technological advances have led to increased interest in crowdsourcing as a means of involving customers and users in generating product ideas. Successful sourcing can result in a large number of ideas, which makes the development process more difficult and costly because it is necessary to screen these ideas and select the best (Di Gangi et al., 2010; Magnusson et al., 2014; Pisano and Verganti, 2008; Soukhoroukova et al., 2012). To reduce the difficulty and cost of processing such ideas, research has focused on a particular type of user and consumer – referred to as a lead user – because such lead users have been shown to have the potential to develop truly novel product ideas and concepts (Von Hippel, 1986). Studies show that lead users have more sales potential (Lilien et al., 2002) and propose more new and commercially attractive products (Franke et al., 2006) than traditional methods of generating market research innovations. In this line of research, certain studies have focused on the characteristics of lead users to better understand and identify these rare subjects.

The first two characteristics of lead users that emerged from prior research are being ahead of trend and having a certain level of dissatisfaction with extant products. The ahead of trend characteristic is related to innovation attractiveness (e.g., Franke et al., 2006, Schreier and Prugl, 2008) because it supports commercially attractive products. In this case, lead users are at the vanguard of important market trends and support innovation by solving future problems in the mass market (Herstatt and Von Hippel, 1992; Von Hippel, 1986, 1988). A lead user's level of dissatisfaction emerges when they identify new needs that are not addressed in the extant market (Von Hippel, 1986, 1988; Herstatt and Von Hippel, 1992). Thus, lead users develop high expectations regarding the benefits of a new solution and their likelihood to innovate is high (e.g., Franke and Von Hippel, 2003; Luthje, 2000). Third, product-related knowledge seems to be essential in finding solutions that improve products. This characteristic of lead users consists of know-how regarding the design of existing products

and of the materials used and technologies available on the market (Lujthe, 2000), which allows lead users to modify the product, make technical changes to the product or develop new techniques to use the product (Lilen et al., 2002; Luthje, 2004; Morrison et al., 2004). Fourth, lead users' product usage experience and technical abilities are related to generating the most innovative ideas (Hienerth et al., 2007), which is supported by Franke et al. (2006) who find that the local resources of users (e.g., their technical expertise) positively influence the attractiveness of innovations. Fifth, user involvement is positively associated with innovative and commercially attractive designs and serves as a method of identifying lead users (Lilien et al., 2002). Luthje (2000) shows that lead users are driven by a strong interest in being informed beforehand and to outdo others, which distinguishes their involvement. Finally, lead users' opinion leadership emphasizes how they are active contributors within the community and how they demonstrate strong leadership (Franke and Shah, 2003; Morrison et al., 2000; Schreier and Prugl, 2008). Lead users may also play an important role in the diffusion of many innovations (Morrison et al., 2004). Urban and von Hippel (1988) suggest that lead users might serve as opinion leaders that accelerate new product diffusion.

Although the literature on lead users has established the importance of being ahead of trend, dissatisfaction with extant products, product-related knowledge, user experience, user involvement and opinion leadership as key characteristics for identifying lead users, the literature is less clear on the validity of these characteristics in an online context and on how lead users may be identified in an idea generation challenge. The aim of this study is to fill this research gap.

Methodology

In the present study, we attempt to explore a relatively new topic in academic research: online lead user identification. The behavior of online lead users has received little attention in the literature. Scant academic research investigates lead users in an online context, particularly during an ideation challenge. In light of the foregoing, we explore the characteristics of online lead users using a case study approach, which is appropriate for developing an understanding of a specific situation and for testing theories in different contexts (Eisenhardt, 1989; Glaser and Strauss, 1964; Robson, 2002; Yin, 2003).

We chose the online platform for a deeper analysis of lead users because outsourcing this type of toolkit makes it possible to examine the value of user and customer involvement (Kristensson et al., 2004). In addition, this platform was selected because of its design

implementation, the freedom associated with it and the support it offers for idea generation (which is better for open and creative tasks than for selecting from a predefined set of ideas). It has been previously suggested that both open and creative tasks can be handed over to customers in an online ideation contest (Piller and Walcher 2006; Terwiesch and Xu 2008). In line with our objective, we first defined the experimental conditions that our study requires and created the Minder online ideation platform. We enrolled 302 respondents to participate in our online challenge to help us create an experimental panel through which we could identify potential lead users. Second, we used screening techniques to select participants who demonstrated innovative capabilities as potential lead users. We selected 25 "lead user" participants from this group. Third, we conducted in-depth interviews to validate the characteristics of online lead users and confirm the lead user status of these 25 participants.

We designed our research methodologically to address both the experimental protocol and the process of data analysis. First, we found inspiration for our experimental protocol in in previous research implying users in context (eg. Spann et al., 2009), which explains the similarity of our approach. Second, we adapted our data analysis methodology from Restuccia et al., (2015), which acted as the model for our epistemological positioning to build typology. In this section, we first describe our experimental protocol in three steps and then explain our data analysis.

Experimental Protocol

We followed a three-step research methodology: 1) we created the experimental conditions using the Minder Platform; 2) we identified potential lead users among the participants; and 3) we validated the typology of online lead user characteristics. Each step is described below.

Step 1: Creation of the experimental conditions: the Minder Platform

Before analyzing lead user characteristics in depth, we had to create the experimental conditions in which users can interact to identify potential lead users. We created these experimental conditions based on previous research that studied users during a co-creation process. For example, Spann et al. (2009) created a virtual stock market in the product category of "movies". The authors evaluate participants' performances to analyze the feasibility of using virtual stock markets to identify lead users (Spann et al. 2009). Kristensson et al. (2004) involves a similar scenario in which examine the benefits of involving users to develop ideas for new products in an innovation project within a co-

creation platform. In Kristensson et al. (2004), participants were tasked with creating value-added for mobile phones during the process of idea generation and evaluation (four panels of scorers in which scorers judged the creative product's originality, value, and realization). Finally, Hienerth et al. (2011) analyze user innovation employing a qualitative methodology that combined interviews and observations of users who were integrated into the business process of companies. In our study, we set up an online crowdsourcing platform, the "Minder platform[3]", which supports the customer's co-creation process. This platform enables user integration at various stages of the innovation process and integrates the expertise of a target population of users. It allows customers' best ideas to be captured by supporting the overall innovation funnel. The platform focuses on concept development from the challenge brief through the development of new ideas. In the present study, the experimental process begins with the launch of the challenge, followed by users developing ideas, concepts and attributes, and ending with the selection and evaluation of the best ideas based on their feasibility and commercial attractiveness. By creating a community of customers, this platform allows us to identify users who are most capable of performing tasks, solving problems and contributing to innovative ideas. In addition, due to the active participation system (comments, votes, and ratings), we can employ users in decision-making processes and to evaluate ideas, concepts and attributes at each stage of the innovation process.

The Minder platform has specific features that are particularly relevant to the present study:

- It can customize domain creation where the ideation process is occurring
- It has statistics on user management
- It can maintain control over who can observe and contribute
- Users can create personal profile pages and interact with other profile pages
- It allows questionnaires to be sent to understand users' profiles

The study focused on an ideation contest related to an emerging technology, i.e., a "tactile tablet". Users were asked to contribute to the next generation of "tablets" by proposing new ideas and improvements for products already available on the market. After our experimental setup was created, we contacted a total of 550 potential respondents representing 174 firms via e-mail with a request to participate in our online ideation contest and online survey. Respondents were assured of their own and their firm's confidentiality. We received responses from 302 respondents representing 104 firms, representing a response rate of 54%.

[3] The website of our platform is available at: www.innovation-minder.com

Thus, by the end of this first step, a total of 302 individuals were set to participate in our online ideation challenge: *Contribute to the next generation of tablets*.

Step 2: Identification and pre-selection of participants with a lead user profile

The main goal of this second step was to identify potential lead users among all participants. In line with the previous literature on lead users, we used screening methods to split up the participants (Franke and Shah, 2003; Herstatt and Von Hippel, 1992; Lüthje and Herstatt, 2004; Morrison, et al. 2004; Schreier and Prügl, 2008; Von Hippel, 2005). This approach is suited to screening a large number of users to test and identify whether they have the characteristics of a lead user (Lüthje and Herstatt, 2004).

We screened our population using the attributes of lead users as criteria (examples of screening questions are presented in Appendix A, Table A1). Because screening surveys are often based on telephone interviews or written questionnaires (Belz and Baumbach, 2010), we posted an online questionnaire to screen respondents directly on the Minder platform. To avoid bias from the ideation context, we sent questionnaires before the beginning of the challenge's brief. At the end of this step, we selected a total of 25 potential lead users from the participants in our sample.

We used two basic criteria for in selecting these potential lead users in our sample. First, using the online questionnaire, we determined individual innovative behavior by identifying who the participants were that suggested innovative improvements for the tactile tablet or smartphone (Franke and Shah, 2003). Second, we included participants who presented some lead user attributes because we wanted to explore these characteristics in an online context.

Step 3: Interviews to validate a typology of online lead user characteristics

In this step, we wanted to better understand the behavior of online lead users by analyzing their characteristics in an online ideation context. Once participants with the relevant characteristics of lead users were identified, we conducted in-depth interviews with all 25 individuals to answer our main research question: How can we identify lead users in an online context? We only interviewed those participants who presented a predisposition to be a lead user – the 25 people selected through our screening – because our research goal was to create an online lead user profile. Respondents included a sample of managers in differing fields of industry from different regions of France (details on respondents are provided in Appendix A, Table A2). Interviews were conducted over a period of three months after the launch of the

online ideation contest. The interviews were conducted in either French or English, at the choice of the respondent, and lasted approximately 45 minutes.

During the interviews, our aim was to explore personality traits, the characteristics of respondents and how they positioned themselves in relation to a pre-established lead user profile. Because we sought to gain insight into the profile of lead users, we asked respondents to speak freely about their perceptions of and feelings about tactile tablets, smart phones and other IT tools. Because the questions were designed to identify the characteristics of lead users in an online context and to evaluate their different attributes, we invited respondents to describe their positions on and feelings toward these lead user attributes. Following the lead user literature (as described in the theoretical section above), we interviewed respondents regarding the six lead user characteristics and their attributes. By answering questions and describing their feelings about these characteristics, these informants confirmed that identifying lead users in an online context differs from the process employed in the previous literature (in an offline context). Further details are provided in the data analysis below.

Data Analysis

Because we are studying a phenomenon that has rarely been explored – the literature provided the building blocks for developing the typology but offered only limited evidence regarding the specific topic in question (Restuccia et al., 2015). With this in mind, we first selected an exploratory design to develop an experimental ideation platform. The goal was to understand online lead users profiles and behavior regarding pre-established lead user characteristics so that we can propose an identification process specific to online users. As a result, we do not take a classical inductive approach because we do not aim to increase the external validity of our research findings or to expand upon an emerging and extant theory (Eisenhardt, 1989). Moreover, our research also does not take a traditional deductive approach because no solid theory has yet been established that we could use to test the characteristics of lead users in an online context and to propose suggestions for their identification (Jarvenpaa and Lang, 2011). Therefore, to investigate the online context of lead user identification, we applied a qualitative approach to explore the scenarios under investigation, as this approach is pertinent for gaining a rich description in the context of typologies (Restuccia et al., 2015; Doty and Glick, 1994).

Next, we applied an abductive approach to investigate our empirical data that followed an iterative process of moving back and forth among our data, emerging concepts and the relevant literature (Corbin and Strauss, 2008; Miles and Huberman, 1994). We used a

computer-supported qualitative data analysis tool, NVivo, to manage the data analysis process. During the data analysis process, we continuously consulted the previous literature. During the coding process, data items were generated that ranged in length from a few words up to several paragraphs. We used the previous literature to construct a terminology and to find definitions to describe our codes and themes (Please see Appendix A, Table A3 for coding examples). In analyzing the data of a specific participants' profile, we considered each lead user attribute and the corresponding characteristics separately to provide a detailed overview of the typology of these online characteristics. For each respondent, we identified several attributes of lead user characteristics, and we constructed a theoretical perspective related to the previous literature. We grouped these attributes together using ahead of trend, consumer knowledge and expected benefit as metrics. Finally, we broke down the general characteristics of lead users into these three subcategories based on the attributes detected.

Finally, our data analysis led to the development of propositions for the identification of online lead user characteristics. Based on our data interpretation, we provide an explanation of the attributes of ahead of trend, consumer knowledge and expected benefit, while making reference to our empirical findings, contextual observations and the relevant literature. We present our findings and propositions development in the following section.

Findings

The analysis of participants in our online challenge unearthed several attributes of lead users that we subdivided into three categories, following the previous literature: 1) ahead of trend, 2) consumer knowledge, and 3) expected benefit. These categories enable us to design an online typology of lead user profiles using lead users attributes and to show the difference between the characteristics of offline and online lead users. The attributes and corresponding characteristics are visualized in figure 1 and explained below.

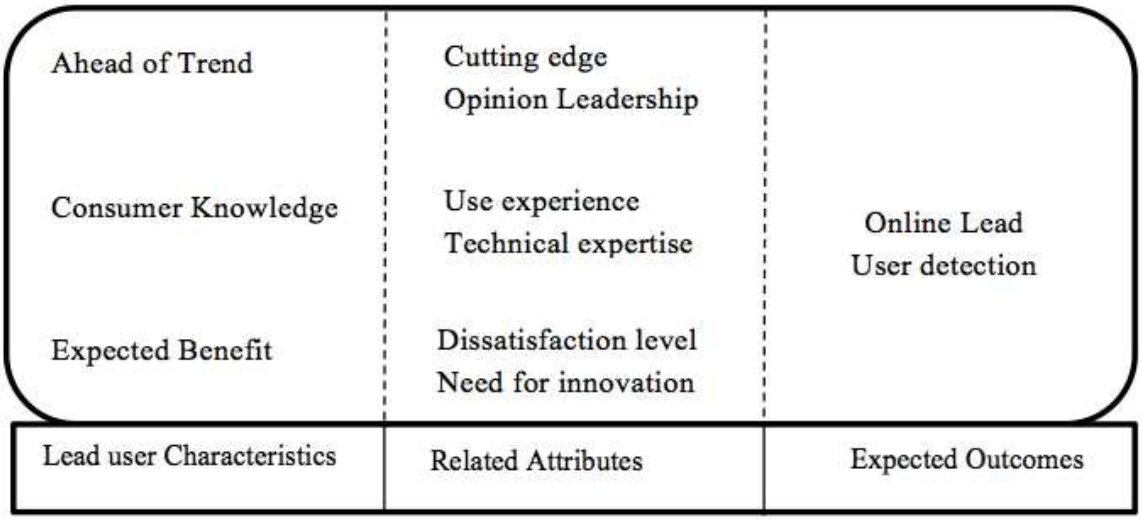

Figure 1: Lead user characteristics and corresponding attributes

Ahead of trend

Ahead of trend – Cutting-edge attribute

The attribute of being cutting edge appears to be required for participants to generate innovative ideas, and interviews confirmed that this attribute is also a characteristic of lead users in an online context. Respondents displayed a natural willingness to explain that it is important for them to know and own the latest innovations for their tablet, and they also acknowledged this tendency with respect to communication technologies in general. These respondents need to be cutting edge. Remaining always up-to-date with respect to this category of products sometimes represents a sizeable investment for users "I like to be on the cutting edge as far as my computer is concerned, in terms of innovation, brands, newness... For example, I recently invested in the latest retractable Lenovo because I need to have the latest or most innovative product in this field. And because I know that tactile screens are going to be made for the computer, I am sure I'm going to want to have one, even if it will be very expensive. I know it represents a huge part of my budget, but it is not a problem for me, I have to invest" (senior production manager, General Electric). The financial requirements of being at the cutting edge of technology is not perceived as a barrier to online participants who desire continuous improvements for their tools. They demonstrated considerable willingness to be aware of novelty in this field: "I like to be informed about the latest innovations, but I do not necessary have the financial resources to own all the last innovations. For example, I heard about the latest Apple tablet, but I cannot buy it, even if I would love to have it! However, for me the most important aspect is to know and find all information about what is

new, how it works, and to have the ability to understand and test it" (Business analyst, Schneider Electric France).

In addition to the technological aspects of being at the cutting edge, one must include aspects that relate to the "design side" of products. Online lead users also seem to pay attention to their tools in terms of style and fashion. "More than the technology aspect, I like to be "fashionable" in terms of design, such as with original tablet bodies, colors, etc. I like to have the latest innovations in terms of aesthetics, size, colors, leather cases, custom cases, snap-on covers… I want to have all the accessories to customize my tablet" (Credit Analyst, Credit Agricole (French Bank).

Among all respondents, 62% indicated that it is very important to them that their tablet is cutting edge. However, our ideation contest study of lead users also indicated that 28% of these respondents are not concerned with this attribute. We observe that these respondents do not focus on being at the cutting edge of their tablets because they only focus on the practical aspects of the product: "I really don't care to be at the forefront of technology, I only focus on practical applications but I don't search for the latest improvements in terms of software or applications. I never upload the latest applications for my tablet and I don't really know them because I only look for applications that I need and that I use daily" (Marketing Communication Manager, Recruitment Industry). They perceive this product as a practical tool in their daily life, but they do not particularly have to obtain optimal use of the product: "I don't see the interest to really develop or explore my tablet to expand its use possibilities. I think it's enough for the way I use it" (Financial controller, Dell France). Although some respondents denied that they had to be cutting edge, our results are consistent with previous findings that this attribute helps detect lead users in an online ideation challenge.

Ahead of trend – Opinion leadership attribute

Related to the ahead of trend attribute, respondents showed a real interest in being an expert in the field of communication technology and made efforts in their everyday lives to improve that knowledge: "I often consult user forums and developer websites, such as XDA (for Android). It's important for me to know the latest versions, to know what is going to work or not for the latest innovations. I often send bug reports to developers, to help them resolve problem, or to improve the product. I like to be an active participant in this community" (MRO buyer, Plastic Omnium). Users are looking for information to improve their knowledge in this field: "I often consult forums at least several hours per week to keep updating my

knowledge about communication tools. This topic is really a part of my hobbies, so I often talk about it with others, and I very often initiate conversations about communications tools with my friends" (Sales Manager, Decathlon France). "Communications tools are very important in my life. I work in an e-business department, so I have to understand how people are linking with the virtual world, and it's very important for me to talk with people about different social media, different tools, and devices, how they use them... I always read newsletters, forums, and websites about communications tools. For me – but also for my job – I have to always be up-to-date to improve my knowledge on this subject. I subscribe to several RSS flux, or newsletter, to keep update in communication tools field. And I am totally passionate about the field of new technology" (e-business manager, Antalis International).

Respondents showed a real ability to help and advise others regarding the use of their tablets and other technologies in this field, and they portrayed themselves as more capable of delivering this type of advice. "My friends ask for my opinion about the latest innovations, and I often help people use their tablets or similar tools. For example, I often advise friends – or post answers to forums or focus groups – about how to convert Power Point to PDF files on tablets, which applications are the most pertinent for specific needs, etc." (Product Manager, France Television). "I like to talk about communications tools with my friends but just with those friends who are expert users like me. I often help my friends to use their computer, and even their tablets! Because they know I am expert in communication tools, I can advise others because I have the abilities. I like to consult user groups to interact with others about communications tools and especially to give my opinions and have opinions in return" (Supply chain manager, ERAI International).

Opinion leadership attribute is confirmed by 90% of respondents who demonstrated a capacity and willingness to develop their knowledge and to be active participants in the community of communication technologies.

Consumer knowledge

Consumer knowledge – Use experience attributes

The use experience attribute seems to represent a lead user characteristic in the context of online ideation – but with a slight difference in that extensive knowledge and interest in similar products allows them to play an important role in the tablet challenge. Some respondents display extensive use experience regarding their tablet, and sometimes even appear to be addicted. "I fully use it in my day-to-day life, all the time, and I think I could not

live without my tablet. This tool is very important in my day-to-day life, at work, at home. Yes, of course, it would be very difficult for me to live without my tablet. Even when I don't really need to use it, for example in holidays, I spend at least three hours a day on it" (Web marketing Manager, EDF France). "I have used it every day since the first tablets were available on the market. So I can say that I have a strong use experience, compared with others, because I adopted it very early. I use it like 10 hours a day!" (Consultant Business Unit SAP, Tech Company).

However, extensive use experience is not necessarily related to being an early adopter. In other words, a user does not need to have extensive use experience in terms of time duration, but more in terms of the manner and intensity of usage "I have had a tablet only for five months, but I use it every day, to always be connected, to interact with others, to be informed, to work… And late adoption is not a problem to fully use it because I have some abilities for this type of tool because I have used similar tools (smartphone) for a long time; I think I use it five hours a day. (Capital Market Manager, One Point Group).

Another important finding that emerged from our interviews is that there are people with no direct experience with tablets or that have never even used a tablet who seem to be confident enough to use it. "I never use a tablet but because I have a smartphone and use it in a sophisticated way, it is not a problem for me to switch to a tablet" (Communication Manager, ERDF). Despite a lack of experience in using tablets, users who have substantial experience with similar products can demonstrate lead user behavior during an ideation challenge. "I have never had tablets, but I'm really interested in communication tools. I often advise people about these kinds of product, and I often help others to improve their use of this product" (Sales Manager, IMB France). In other words, people who are not familiar with a specific product may still demonstrate a willingness to use it or talk about it if they must. In the specific context of our ideation challenge, our respondents were confident about their abilities to have innovative ideas: "I am not really familiar with the use of tablets, but regarding the challenge on Minder, I'm sure that I proposed more innovative ideas than many people who have one. Because I'm really interested in this type of products and even without use experience I know how to use it better than the others". (Buyer, ERDF)

The use experience attribute is related to 52% of the respondents, and it appears that the remaining 48% maintain that an extensive knowledge of and interest in similar products allows them to be active and helpful in our particular online ideation challenge. The direct implication of this finding is that use experience attributes can be used in an online challenge

to detect lead users who are not necessarily users of the target product but instead of the product family.

Consumer knowledge – Technical expertise attribute

The technical expertise attribute follows the same paths as previous attributes discussed above because it appears to represent a characteristic of lead users in our online ideation context. Moreover, extensive knowledge and interest in similar products allows these users to use their acquired technical expertise to make substantial contributions in the tablet challenge.

First, to suggest useful and innovative ideas for the ideation challenge, 65% of the respondents indicated that they had strong technical expertise in the use of their tablet. "I could be qualified as a power user. I implemented new software on my tablet to improve its performance, and I did it alone. I think I like to develop expert knowledge regarding this type of tools; it's like a hobby. I can say that I'm an expert user because I am very interested in the graphic design task also, which requires a particular use and an extensive knowledge of tablet use because it's not the main goal of this type of tool. I think that I use it in a unique way compared with others because I use it for video editing and graphic creation or design, and few people have this type of knowledge or competences in terms of use" (Business Manager, Dell France). Another aspect of this attribute is that online lead users qualified their way of using the tablet as very special compared with other users. "For me, there are different ways to use this kind of tool. You have one person who only uses a tablet to go on the Internet, check emails or something like that. And the one who fully uses all the tablets' features as a real work tool, in downloading applications or software that don't initially exist, in improving RAM, graphic cards...I'm more as this type of user, which qualifies me as an expert user" (Marketing Manager, Volkswagen France).

Second, 35% of respondents did not exhibit particular forms of knowledge or abilities in their usage of tablets. It seems that a user who has no specific knowledge of tablets can still be categorized as a lead user if he has extensive knowledge of the product family and can be attributed with use experience as a result. Moreover, what is important is a strong knowledge of the same field of technology or of similar products, such as, for example, smartphones or laptops: "I know the product but I could not be qualified as an expert. However, if I have to use or help someone use a tablet, I have the ability to do so because I already developed this knowledge with my smartphone, and I already developed some abilities for tactile tools" (Digital Project Manager, SNCF). As a consequence, it appears that if a user shows product-

related knowledge in a field, he can apply this knowledge to other products in this field although he may not have concrete experience in using these specific products.

It seems that users who do not have technical skills with the tablet can also be qualified as lead users due to their technical experience with similar products. In fact, technical skills related to similar products in the field of communications technology alone are enough to redefine the user as a lead user for the tablet. "I made changes on my smartphone to improve it, and if I have to, I could do the same for a tablet" (Sales operation junior manager, Orchestra). "I am always looking for improvements for my smartphone; for example, I recently imported new software, and I am sure that I can do the same on a tablet because it requires similar competences" (International leisure sales, Avis Budget Group). We believe that extensive knowledge of digital technologies indicates that certain users are predisposed to developing the technical capabilities for tablets and thus take on the challenges in online ideation contests.

Expected benefits

Expected benefits – Dissatisfaction attribute

The dissatisfaction attribute was not found to fit within the profile of lead users in an online ideation contest: "[W]e can find some negative aspects, but these are not really important to my own use. For example, sometimes I have to use my computer instead of my tablet to work on Word or Power Point. However, it's not really a problem for me because it's not a daily problem" (Development manager, Expert Recruitment). For example, several interviewees prefer to use their computer instead of their tablet, but this preference is not considered a matter of dissatisfaction with the product's features from their perspective. "When I have to use my computer instead of my tablet I don't see it as a defect because I didn't buy my tablet to replace my computer" (Business manager, Orange Business Services). Negative aspects of tablets were brought up during interviews but none of these concerned a technical aspect. "I would like the tablet to offer more color choices, but I don't think that is a reason for dissatisfaction. I find that we cannot personalize our applications enough. For example, everyone can download the same application. I would like to have the possibilities to create personal applications based on my own needs. For example, I have one application for a GPS, another for measuring my running time and another that calculates calories spent, but I haven't found one that can integrate all these features that I need. However, I can't say that it's really a problem for me – I'm not dissatisfied – it is more a suggestion or a part of my

imagination!" (Logistical and business operator, PSA France). In addition, some people never voiced any negative comments about the tablet: "I am totally satisfied with the existing products, I never even think about what I don't like!" (Financial controller, Dell).

For that reason, we noted that the majority of people (95% of respondents) never perceived any dissatisfaction regarding the product, and when we asked them to find some negative aspects they became unsettled: "I don't know, I never thought about that… because how could I be dissatisfied and use it every day? Maybe I don't know all the features of my tablet, but I can't find negative aspects that hinder my use, and there is no specific features of my tablet that are totally dissatisfying." (Business manager, Orange Business Services, France).

Expected benefit – Need for attributes of innovations

Following the results of the previous attribute, participants did not demonstrate a need for innovation regarding the product. An ideation contest, however, can trigger an awareness for innovation. Because they are not dissatisfied with the existing product, it might be expected that they do not feel the need for the product to be improved. However, we found that the perceiving the need for innovation is more related to the user's own abilities to imagine improvements as well as to having an innately curious personality. Creativity and curiosity can be triggered by an online ideation contest. "I already imagine improving the design of tablets. For example, I already customized my tablet case and created a 3D case, and a few mounts later, I found the same prototype on the market that proposed a much customized tablet case. So, yes, I often think about design improvements for this product. However, I think it's more related to my taste for design or fashion than really focusing on the tablet's technical aspects or modifying some features to improve it" (Credit Analyst, Credit Agricole, French Bank). Thus, an important aspect of this attribute is that a tablet user's perception of a need for innovation is not necessary related to dissatisfaction levels or expectations regarding improvements that the product must have. "I'm always looking to improve my tablet but just because I like it and not because I'm not satisfied. For example, I installed the last OS version. I did not really need it, but I like to have every innovation for this kind of tool. I often try new things on my tablet to improve it. I also tried to implement new software with my computer to improve photo quality on my tablets" (Sales Manager, Decathlon, France). We found that 75% of the interviewees did not show that they felt any particular need for innovation when using products available on the market. However, it is important to note that an ideation contest and the challenge's brief itself may give rise to the idea that there is a perceived need

for innovation. "Yes I am satisfied with my tablet, but if I have to find improvements for it, of course I will find it" (Sales Manager, Decathlon, France). In this context, extensive user knowledge of communication technologies in general contributes to their capacity to find innovations for the tablet. "I already wanted to improve my smartphone to have more possible uses, and I have similar ideas for the tablet. And I'm sure that it can be helpful to respond to the challenge" (MRO Buyer, Plastic Omnium). In summary, we found, first, that participants do not innovate because they want to improve negative aspects of the product but because they have a natural tendency to try new things related to their products. Second, the context of the ideation challenge seems to be a motivating factor for participants to envision the innovation possibilities.

Propositions

The experimental online ideation challenge suggests a distinction among three characteristics – ahead of trend, consumer knowledge and expected benefit – that are relevant to the profile of online lead users. In the context of an ideation challenge, we argue that these characteristics are crucial to firms to identify online lead users. First, the Minder platform underscores that online user interaction is a productive area to generate and assess ideas (Baldwin et al., 2006; Jensen et al., 2014) and that ideation contests using crowdsourcing tools can positively help identify innovative users (Potz and Schreier, 2012). Second, the study provides a typology of the characteristics of online lead users, which further assists their identification in the specific context of ideation. In the following section, we present the development of our theory, develop testable propositions, and we explain their managerial implications.

Ahead of trend

Innovative users who tend to be lead users are "ahead of the field" compared with non-lead users (Franke and Shah, 2003) and are most likely to develop valuable innovations (Von Hippel, 1986). This notion is based on the assumption that new needs typically spread slowly across markets and market segments rather than impacting all customers simultaneously (Von Hippel, 1988). By deeper analysis of the ahead of trend characteristic, prior studies have shown that "cutting edge" users are more likely to develop innovative solutions because they do not have to imagine themselves in a situation that does not yet exist (Luthje and Herstatt, 2004). In addition, this characteristic of lead users had been described as being the essence of opinion leadership (Spann et al., 2009) because opinion leaders are the first to buy new

products and to communicate their user experiences of the new product in their social networks (Childers, 1986). Empirical research on this characteristic of lead users has shown that these two attributes – being a cutting edge user and opinion leadership – are important components of being a lead user. For example, Lilien et al., (2002) demonstrated that integrating cutting-edge users into the corporate product development process is highly promising as a means of achieving breakthroughs. However, few studies have examined the attributes of lead users in the context of ideation challenges, and particularly in online contests, insofar as these attributes help identify lead users in this specific context. However, it had been shown that lead users tend to be those who come up with the most commercially valuable ideas in online communities (Jeppensen and Frenderiksen, 2006).

As explained in the methodological section above, we applied these two attributes to identify lead users and to check their validity in the context of an online ideation challenge.

The cutting edge or so-called leading edge attribute defines users who are ahead of their time compared with other users because they already "live in the future" (Von Hippel, 1986). As opposed to ordinary users, lead users are already familiar with the "new" because they know and experience a product or a trend before others (Hienerth and Lettl, 2011). This significant advance in the knowledge of a technology or a product allows lead users to develop important innovations due to their willingness to constantly update their products' features or functionalities (Franke and Shah, 2003; Franke et al., 2006; Morrison et al., 2000). With respect to the second attribute, opinion leadership, previous research demonstrates that opinion leadership is often considered the central characteristic of lead users (Bilgram et al., 2008; Luthje and Herstatt, 2004; Von Hippel, 1988), which implies that other consumers will ask such opinion leaders for information and advice. The lead users in our study demonstrated a strong capacity to help other users use their tablets more effectively and indicated they liked the status of advisor. These lead users also demonstrated a strong capacity for sharing information with other users in the same community via forums, chat groups, websites, etc. Franke and Shah (2003) show that innovators report taking a more active part in the community, partake in more non-sport related activities with other community members, and feel more strongly that the community should take their opinion into account when making decisions than non-innovators. In the context of online ideation, we found that interaction with others is likely to help users to find innovative solutions to challenges.

Our study provides empirical evidence that a majority of pre-determined lead users powerfully demonstrate the following two attributes: being at the cutting edge and opinion

leadership, both of which are required to identify lead users in an online ideation context. Thus, we suggest the following proposition:

Proposition 1: The cutting edge position of a user and his or her position as an opinion leader in this field are prerequisites for determining the ahead of trend characteristic, which is required to identify lead users in an online context.

Consumer knowledge

Luthje (2004) demonstrates in an empirical study that the level of user expertise is positively related to the practical improvements in a product because lead users must be knowledgeable to understand specific products. Lead users, therefore, typically need technical abilities to change the technical aspects of a product and to modify or improve it. Furthermore, use experience emerges with the frequent use of products (Luthje and Herstatt, 2004) and it has been shown that high levels of use experience directly impacts the level of lead users (Schreier and Prugl, 2008). Moreover, lead users tend to have a high level of use experience with specific products that they use. For example, Schreier and Prugl (2008) studied extreme sports communities and showed that lead users tend to possess more consumer knowledge and use experience in the relevant field. They also found that lead users tend to adopt new products before other consumers. Various studies in this field provide strong support for the link between the level of experience and knowledge, on the one hand, and user innovation efforts, on the other (Franke and Shah, 2002; Lilien et al., 2002; Von Hippel, 1988). Based on this assumption, we posited that consumer knowledge includes these two attributes, and both seem to be prerequisites to identifying the extent to which an individual can be considered as a lead user (Schreier and Prugl, 2008). However, these findings are slightly at odds with the established literature because we found that one can still be considered a lead user even if components of these two attributes are not entirely verified. First, we found that lead users do not always require extensive use experience with a product. Respondents explained that a strong familiarity with the use of a tablet is not necessarily required for a user to be a lead user. Instead, familiarity with a similar product is enough to provide innovative solutions for products in the same field in the specific context of our ideation challenge. Second, we found variations in the second attribute of consumer knowledge: technical expertise. Our results show that lead users do not have to be experts on the product or have extensive knowledge

about the product but that they should have expertise in the family of products to be identified as a lead user and to provide the expected added value for firms.

Therefore, these two attributes – use experience and technical expertise – were aggregated to describe the characteristics of consumer knowledge. This characteristic identified participants in our challenge as those who would develop innovative ideas. Online lead users did not demonstrate extensive consumer knowledge about the specific product – the tablet – but did know the family of products. This finding contradicts the previous literature. Consequently, we suggest the following proposition:

Proposition 2: The consumer knowledge characteristic – defined as use experience and technical expertise – not only the specific product but also the product family, remains a prerequisite to identifying lead users in an online ideation context.

Expected benefit

For several product categories, it was shown that the greater the benefit a user expects from a novel product, the greater his or her willingness is to devote resources to find a solution (Morrison et al., 2000; Riggs and Von Hippel, 1994; Von Hippel, 1988). Lead users face needs that existing products on the market do not cater to and the expected benefit characteristic represents the user's willingness to respond to those needs. To measure the expected benefit variable, Franke et al. (2006) explored the items comprising this characteristic more deeply and provided certain clarifications. According to these authors, expected benefit is related to 1) a certain frustration with the unsolved problems of a particular product and 2) a constant search for improvements to this product.

In short, expected benefit relates to two main attributes: user dissatisfaction and subsequently, the need for innovations to correct this dissatisfaction. In the present study, we define the characteristic of expected benefit as a feeling of discontent, in addition to the related needs of a user that concern any aspect of the tablet. The need for the innovation attribute, therefore, refers to the willingness of users to continuously search for better uses for their tablet. The previous literature indicates that this expected level of benefit motivates lead users to innovate (Von Hippel, 1986). Luthje and Herstatt (2004) showed that the heterogeneity of market needs leads to dissatisfaction among many users regarding what manufacturers have to offer. "In this situation, some users who actively want to improve their situation may take the

initiative to improve or develop products themselves" (Luthje and Herstatt, 2004). Therefore, this characteristic can be used as an indicator of innovation likelihood (Franke et al., 2006).

The results of our study are completely in contradiction to this theoretical background. We found neither that respondents are dissatisfied with their tablet nor, more specifically, that users are prevented from fully using their tablets. As discussed above, both the dissatisfaction level and need for innovation are logically linked together because users strive for product improvement to overcome their dissatisfaction. However, notwithstanding a lack of dissatisfaction, we note that users can nonethegap

arrive at relevant and innovative ideas for tablet improvement during ideation challenges. The previous literature (e.g., Franke and Shah, 2003; Jeppensen and Frenderiksen, 2006; Lakhani and Von Hippel, 2003; Von Hippel and Von Krogh, 2003) has shown that the underlying motives for individuals to contribute to collective innovation processes are informed by a mix of intrinsic and extrinsic rewards and that these motives are encouraged by toolkits for user-generated design (Jensen et al., 2014). Our findings demonstrate that the interaction of users in an online context – strengthened by the motivation inherent in the process of an ideation challenge – can overcome lead users lack of dissatisfaction. In other words, online participants were not dissatisfied and still managed to develop a capacity to innovate. Based on this result we propose the following:

Proposition 3: In an ideation context, the characteristic of expected benefit, defined as product dissatisfaction and the related need for innovation, is not relevant to identifying lead users in an ideation context because motivations to innovate that are inherent to the challenge inhibit this characteristic.

One of the major difficulties in having lead users provide innovative ideas is to identify this group in the first place (Lilien et al., 2002; Luthje and Herstatt, 2004) and this problem looms largest in the field of consumer goods (Schreir and Prugl, 2008). However, using the characteristics of lead users has already been shown to be an effective way of identifying them (Spann et al., 2009). Our research contributes to the previous literature by testing this theoretical background in an online context, which is an area that has not yet been explored. We provide an understanding of the profiles of online lead users and a typology of the characteristics of lead users to demonstrate how to identify this type of user in an online ideation challenge.

Participants in our online challenge demonstrated certain specific characteristics that have helped us develop a typology of the characteristics of online lead users. In the discussion above we explained that we compared offline and online characteristics to portray what the profile of an online lead user looks like and to facilitate the identification of lead users in the context of our ideation challenge. In Table 1, we summarize the development of offline and online lead user characteristics and the differences between them as they emerge from our experimental data, and we further provide a typology of the characteristics of lead users.

Offline Characteristics		**Online characteristics**
Ahead of trend (Von Hippel, 1986)	Evolution to the online context → (Potz and Schreier, 2012; Spann et al., 2009)	Ahead of trend - cutting edge position - opinion leadership behavior
Opinion Leadership (Franke and Shah, 2003)		
Use experience (Hienerth et al. 2007)		Consumer Knowledge - Technical knowledge and experience with respect to the overall field-related product
Product-related knowledge (Morrison et al. 2004)		
Expected benefit (Von Hippel, 1986)		Need for Innovation - Challenge-related need for innovation
Involvement (Luthje, 2003)		

Table 1. Typology of the characteristics of online lead users

Conclusions

Our work has examined the identification of lead users in an online ideation challenge and has provided an understanding of the defining characteristics of online lead users: being ahead of trend, having consumer knowledge, and having expected benefit. We have identified and constructed a typology of the characteristics of lead users, which is required to better understand their profile and to identify difficult to find lead users in online contexts. We conceptualized the specific attributes for identifying online lead users and developed propositions to contribute to the identification process of lead users via crowdsourcing tools such as an online ideation platform. Below, we discuss our findings and propositions and explain the implications for both theory and practice. We conclude by noting several limitations of our study and by proposing suggestions for further research.

Discussion and implications

Empowering customers encourages them to develop new ideas and design their own creations, thus engaging them in the process of new product development. In addition, technological advances and the development of toolkits to facilitate user innovation presents an alternative approach to incorporating innovative users (Von Hippel and Katz, 2002). This phenomenon calls for the development of practices that help firms effectively and efficiently select innovative users. In this paper, previous research on identifying lead users is used as a reference point to locate promising users who develop breakthrough ideas and to facilitate their identification in an online context.

After screening 302 users interacting on our experimental ideation platform, we found that 25 of them have the characteristics of lead users. Interviews with these 25 lead users allowed us to develop a typology of the characteristics of an online lead user. First, our study confirms that the ahead of trend characteristic is essential for the production of innovative ideas because online lead users possess the cutting edge and opinion leadership attributes that are also important in the offline context. Second, we find that online lead users possess certain knowledge regarding the field-related product but not necessary knowledge of the specific product itself, which is a slight difference from the offline context. Third, we do not find that there is a significant relationship among dissatisfaction, users' need for innovation and the production of innovative ideas because lead users seem to derive the motivation to innovate from the context of the challenge itself. The findings of this study have implications for both

the theory regarding and the practice of open innovation and user innovation management. The following section discusses these implications.

Implication for theory

With regard to theory, the concept of lead user has received much attention in recent management research. Scholars have addressed this topic from different angles (Jensen et al., 2014), including the following: 1) the process and effects of involving lead users; 2) the innovation effects of user design; and 3) identification of lead users. We paid particular attention to this last area of research because our study was driven by the following question: How can we identify lead users in an online context? Previous research has shown that lead users are part of the user community and that different approaches can be used to identify lead users by utilizing the nature of their characteristics, such as screening (e.g., Franke and Shah, 2003; Franke et al., 2006; Morrisson et al., 2002), pyramiding (e.g., Von Hippel et al., 2009) or netnography (Belz and Baumbach, 2010). This study examined these characteristics during an online ideation challenge and we suggest that the profile of an online lead user differs from that of an offline lead user. Indeed, as we discuss in the theoretical section, numerous authors have found that the possession of each characteristic is positively related to the lead user's capacity to innovate (e.g., Franke et al., 2006; Luthje & Herstatt, 2004; Schreier and Prugl, 2008; Von Hippel, 1986, 2005).

Our study confirms that the ahead of trend characteristics have a positive impact on users' capacity to generate innovative ideas in an ideation contest. More specifically, we found that a sizeable majority of lead users have two attributes – being at the cutting edge and opinion leadership – as essential components of the ahead of trend characteristic. This finding suggests that the ahead of trend characteristic is fundamental to identifying lead users.

However, our findings on the consumer knowledge and expected benefit variables contrast with the previous literature on lead users. Previous research has offered an offline view of these characteristics and shown that neither of the two dimensions can be omitted without posing problems to the identification of lead users (Franke et al., 2006; Schreier and Prugl, 2008). We contribute to research on the identification of lead users by showing that these two characteristics differ when placed in online contexts such as an ideation platform. First, our findings suggest that a lead user does not have to be an expert on the product or have an extensive knowledge of the product but that knowledge of the family of products suffices to

be considered a lead user and to generate innovative ideas within an online context. Consequently, when users interact in an online context, knowledge of and expertise in the family of (field-related) products – not necessarily expertise about the product itself – is enough to identify users that match the profile of lead users.

Second, this study also reveals that lead users do not have to feel dissatisfied or be aware of existing needs to propose innovative suggestions that lead to the improvement of products, which contradicts the previous literature regarding offline lead users. Stock et al. explain in their recent research that the rewards associated with product development importantly include "process rewards", such as fun and learning that can also have a major impact on participation in innovation and on innovation outputs (Stock et al., 2014). Our findings on the variable of expected benefit are consistent with this argument. Moreover, our face-to-face interviews with lead users indicate that the dissatisfaction level and need for innovation attributes are inhibited by motivations that are induced by the context of the ideation challenge itself. Because participants are highly motivated by the contest, they are able to produce innovative outputs without previously having focused on what type of improvements are necessary for the product. Hence, our study brings attention to the theoretical implications that the offline view is critical to identifying lead users via crowdsourcing tools. However, we also find some evidence that certain characteristics of lead users – being ahead of trend, having consumer knowledge and having expected benefit – are different in the online context than in the offline world. Simultaneously, research in open innovation and user innovation has examined the use of online data for forecasting lead users (e.g., Franke and Shah, 2003; Von Hippel et al., 2009). Our results show that it is possible to identify lead users by means of an ideation platform that is constructed to investigate the profiles of lead users and their online characteristics.

Implications for practice

Advances in technology have enabled interconnectivity among individuals via social networks, which has made users a strategic target for companies. Having the right technology-based system can enhance the customer experience and help companies improve both their innovation and customer relationship management capabilities (S. Nambisan and P. Nambisan, 2008). However, it remains difficult for companies to identify lead users in consumer markets, and when they do find them they are few in number (Hoffman et al., 2010). Our research contributes in several ways to improving the new product development

process for customers and lead users in particular. Our study shows that online ideation platforms offer a particular context suited to identifying lead users. In using such tools, companies might also improve their abilities to identify lead users. It is important for firms to recognize that an ideation contest presents a powerful tool to interact with subjects such as lead users that are relatively rare, which may result in companies enhancing their new product development process. Moreover, the cases of Dell or Lego show that firms are often confronted with too many ideas from the online user community and are not able to filter out all but the most innovative (Potz and Schreier, 2012). Our ideation platform proposes filtering ideas through an idea selection process and helps identify online lead users by supporting the development of a lead user typology. This typology will lead to a better understanding of lead user profiles and might help companies improve their predictions regarding innovative idea assignments via idea generation toolkits.

It also can be useful for firms to understand how using toolkits such as ideation platforms can improve the identification of promising ideas. Spann et al. (2009) suggest that a platform that integrates idea sourcing with idea selection also reduces the managerial selection of ideas because the platform already performs this task (Spann et al., 2009). Our experimental study on the Minder platform offers the possibility of empirically demonstrating this finding. By filtering out the remainder and voting for the most innovative ideas, participants reduce the number of ideas put forward at the end of the challenge, which highlights the financial and time benefits for firms that use this type of tool.

Limitations and suggestions for future research

The present study has some limitations that highlight the need for further research. First, this study analyzed only one category of products in a specific field of the consumer market. Future research should use ideation platforms for the detection of lead users that include other product categories and other segments of the consumer market. Such additional research would allow for comparisons to be made across different product categories, and would confirm those characteristics required to identify lead users in such environments. Second, in light of our qualitative approach, we believe that a quantitative approach might help us better understand the different relationships between the characteristics of lead users and their roles in defining the profile of lead users. Such further analysis will help us confirm the identification of online lead users in markets for consumer products. Third, our study used data from our own experimental platform, the Minder platform. Although we believe that our

experimental context can be considered as representative of other idea generation toolkits on the Internet, we propose that this study should be extended to other crowdsourcing tools. Additional efforts in this line of research might struggle with the wide variety of online data. Finally, the challenge brief of our study proposed that we would "invent the next generation of tablet", which is a relatively open assignment with little guidance. However, the innovativeness of users' ideas substantially depends on the nature of the specific problem and how users are asked to contribute. Therefore, future research might analyze the differences between various open assignments and challenges to evaluate the impact on the identification of lead users and their motivation to participate.

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Appendix A

Table A1.

Screening approach: this table presents the different criteria and questions used to identify potential lead users.

Criteria		Example of screening questions
Innovation Activity		Have you ever imagined improving a tablet or a smart phone? Do you think that you use the tablet or a smart phone in a different way?
Lead User Attributes	Product-related knowledge	Do you know the latest innovations for Samsung/Apple tablets?
	Level of dissatisfaction	Do you ever face problems that cannot be solved using tablets or smart phones?
	Ahead of trend	In discussions concerning smart phones or tablets, which of the following happens most often: a. Your friends tell you about it. b. You tell your friends about it.
	Use experience Involvement	How long do you use a tablet or a smart phone each day? Do you often consult websites or forums to learn about tablets or communication tools?
	Opinion Leadership	If one of your friends does not like a tablet or a smart phone, what is your likely reaction?

Table A2.

Minder Platform Interviewees Details

Respondents profession	Company
MRO Buyer	Plastic Omnium (French company)
Senior Production Manager	General Electric
Sales Manager	Decathlon France
Credit Analyst	Credit Agricole (French Banque)
Business Manager	Dell France
Marketing Communication Manager	Volkswagen France
E-business Manager	Antalis International
Business Manager	Orange Business Services
Logistical and Business Operator	PSA France
Business Analyst	Schneider Electric France
Supply Chain Manager	ERAI International
Business Unit Capital Market Manager	Groupe onePoint
Webmarketing Manager	EDF France
Digital Project Manager	SNCF
Development Manager	Expert Recruitment
International Leisure Sales	Avis Budget Group
Consultant Business Unit SAP	Tech Company
Financial Controller	Dell France

Respondents profession	Company
Marketing Communication Manager	Recruitment Industry
Product Manager	France Television
Buyer	ERDF
Communication Manager	ERDF
Sales Managers	IBM France
Financial Controller	Dell France
Sales Operation Junior Manager	Orchestra France

Table A3.
Coding example for identification of lead user attributes

Coding rules for determining whether respondents present the corresponding attributes **- Definitions**	*Technical expertise*: interviewees presenting technical knowledge or abilities *Dissatisfaction*: interviewees present a strong level of dissatisfaction regarding the product. *Cutting edge*: interviewees demonstrate advanced interest in the product compared with ordinary users. They demonstrate a strong interest to the field of communication tools; they are fascinated by the product. They want to get the product before and know it better than other users. *Use experience*: interviewees have used the product for a long time, even before ordinary users demonstrated interest in this type of product. *Need for innovation*: interviewees have unsatisfied needs regarding the tablet and have already reflected on how they can improve certain aspects of the product. *Opinion leadership*: interviewees are able to teach others about the product; they participate in the related community (forum discussions, blog…).
Some examples of coded statement	"It is very important for me to be at the cutting edge for my smartphone, I always know about the latest applications or innovations regarding my smartphone. It is important for me to always improve my smartphone." Coding→ *Cutting edge* "I often consult forums and developer websites, such as XDA, referring to Android developments." "It's important for me to know the latest versions, to know what is going to work or not for the latest innovations." "I often send bug reports to developers to help them resolve problems or improve the product. I like to be an active participant in this community." "I often help other use the product, and I often begin to speak about last innovations or the like because I really care about the subject of communication tools." Coding→ *Opinion Leadership* "I could be qualified as a power user. I implemented new software on my smartphone to improve performance, and I did it alone." "I think I like developing expert knowledge regarding this kind of tools; it's like a hobby". Coding→ *Technical expertise*

Article 2

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OSS Popularity: Understanding the Relationship between user-developer interactions, market potential and development stage

Nassim BELBALY*, Clémence CHERUY*, Frank ROBERT*

* Montpellier Business School

ABSTRACT

Abstract

Following the growing interest and concerns regarding the open source software (OSS) phenomenon among academics and practitioners, many studies have been conducted to understand the factors that influence OSS success. However, research has primarily explored such factors in the context of well-known projects, such as Linux and Apache. However, less known projects must be examined to gain a more complete understanding. Accordingly, this paper focuses on less known projects to examine three factors that influence OSS popularity: user-developer interaction, market potential and development stage. Specifically, we develop an empirical model of OSS popularity and test our hypotheses on data from 657 open source projects. The findings show that the combination of the three factors has a positive effect on OSS popularity. Moreover, in contrast to previous research, the results reveal that exchanges among users and developers have a stronger influence on OSS popularity than bug-related activities. Overall, this research provides a novel way to measure OSS popularity for less known projects and a better understanding for organizations.

Keywords: Open source software, software development, OSS popularity, user-developer interaction, market potential, and development stage

I. INTRODUCTION

Although the Open Software phenomenon (OSS) has for a long time been characterized by the collaboration of volunteers who supply their work for free (Benbya & Belbaly, 2010), this phenomenon has progressively evolved toward a more commercially viable form labelled OSS 2.0 (Fitzgerald, 2006). The notable success of key OSS projects, such as the Linux computer operating system and the Perl programming language, has increased academic interest in OSS (Von Hippel & Von Krogh, 2003; Crowston et al., 2012), and such interest has been nurtured by the need to understand the high failure rates of OSS projects in order to improve their overall success (Fitzgerald, 2009; Sutanto et al., 2014). Accordingly, numerous studies have focused on determinants of OSS project success (Crowston et al., 2003, 2006; Fiztgerald, 2009; Midha & Palvia, 2012) by examining for instance the influence of developers' motivation (Stewart et al., 2005; Meissonier et al., 2010), user utility (Stewart et al., 2005), internal cohesion (Singh et al., 2011) and developers' technical achievements as well as indicators of market success (Grewal et al., 2006), in order to better understand how OSS projects become performing.

However, the definition of OSS success is highly disputed as it has different meanings across projects and stakeholders (Crowston et al., 2003), and has some difficulties to be measured. Some studies have proposed OSS popularity as a valuable indicator of OSS project success, especially for less known project (Stewart & Ammeter, 2002; Crowston et al., 2012). However, research on the factors that influence OSS popularity remains limited, and the few existing studies mainly focus on user involvement (e.g., Von Hippel & Von Krogh, 2003), the support network (Sutanto et al., 2014, Capra et al., 2011), project-specific characteristics such as the project age, software user license or target users (Stewart & Ammmeter, 2002) and network embeddedness (Grewal et al., 2006).

Consequently, further research is needed to examine OSS popularity by investigating other factors or combinations of factors in order to create new knowledge on open source projects (e.g., Von Hippel & Von Krogh, 2003; Singh et al., 2011). Evaluating OSS popularity based on the combined effect of the market potential (Grewal et al. 2006), user-developer interaction (Wagstrom et al., 2005; Barcellini et al., 2008; Iivari, 2009), and development stage (Stewart & Gosain, 2006) constitutes a different and logical way of determining the success of OSS projects. These factors can benefit from recognition of their joint effects on users and developers, and project administrators or organizations. Further, a better understanding of the role of OSS actors would allow organizations to develop a favorable environment for

stimulating and fostering OSS development. Although the three above mentioned factors have been studied separately, there is little evidence regarding their combined explanatory power for OSS success. Therefore, we believe that jointly focusing on market potential, user-developer interaction, and development stage may be a possible way to gain a better understanding of OSS popularity.

While market penetration is often used to examine well-known projects such as Linux and Apache (Gallivan 2001; Mockus et al. 2002), the popularity of a project among potential users constitutes a similar indicator that can be used for other OSS projects. These other OSS projects can include projects with much lower levels of participation and prominence, which are more representative of the majority of OSS projects (Stewart et al; 2006; Krishnamurthy 2002). Less known projects are defined as projects that are not yet popular (renowned) in the community. Hence, by measuring the general level of interest in a project (i.e., its popularity), we can better understand how OSS projects attract interest and input from the user-developer community; we can also provide a better way of assessing the overall success and quality of OSS projects. This study thus aims to explore less known projects in order to obtain such evidence.

This research specifically investigates the following research questions: Does the combined effect of user-developer interaction and market potential lead to greater OSS popularity? Moreover, how does the development stage of a project influence this combined effect on OSS popularity? To answer our research questions, we tested our model by using data on 657 open source projects hosted by Sourceforge.net that were focused on enterprise application development. The results indicate that the combination of market potential, user-developer interaction and development stage has a positive impact on OSS popularity.

We proceed as follows. The second section presents the theoretical background which includes a first part dedicated to previous research on OSS success, a second part where we explain the notion of OSS popularity, and a third part presenting our conceptual model and formulation of hypodissertation regarding the factors that affect OSS popularity. The third section then presents the methodology used to test the model and the data analysis, and the fourth section reports the results. The implications of the results for theory and practices are subsequently discussed in the fifth section. Finally, the paper concludes with the limitations of our research and avenues for future research.

II. THERORETICAL DEVELOPMENT

It is now understood that more and more companies are opening their borders as a powerful way to gain and maintain competitive advantages. This openness is often characterized by the use of crowdsourcing techniques in order to catch external features and innovative solutions from the crowd (Jeppesen & Lakhani 2010). Firms can benefit from a larger solver population because it obtains more diverse solutions coming from diverse external sources (Terwiesch and Xu, 2008; Howe, 2006; Brabham, 2008). The benefit of going out to look for the knowledge needed has been well quoted by Sun Microsystems co-founder Bill Joy, "No matter who you are, most of the smartest people work for someone else" (Lakhani and Panetta, 2007). However, we need to examine the concepts of crowdsourcing and openness, such as open source and open innovation to understand their differences and relationships (Rouse, 2010; Schenk and Guittard, 2011; Chesbrough et al. 2006). Crowdsourcing was first coined by Jeff Howe (2006) as "the act of taking a job traditionally performed by a designated agent and outsourcing it to an undefined, generally large group of people in the form of an open call." Crowdsourcing might be used for open innovation initiatives, but it is not limited to such (Hetmank 2014), as open innovation is considered as "the use of purposive inflows and outflows of knowledge to accelerate internal innovation, and expand the markets for external use of innovation, respectively" (Chesbrough et al. 2006). On the other hand, the main difference between crowdsourcing and open source is on how the company makes use of the intellectual property. The intellectual property is usually transferred to the company that issued the task for crowdsourcing, whereas open source licenses grant the right to copy, change, and redistribute (Guittard, 2011). Because open source refers mainly to software in which the source code -which is developed by geographically distributed developers -paid or not- is made available to the general public (Hetmank 2014).

In our case we are going to focus on open source using a crowdsourcing platform made for OSS development -Sourceforge-. This platform integrates developers and user's interactions with the aim of developing software's available for the public. The main topic is to understand the impact of user-developer interactions on the OSS performance. In fact, the aim of this paper is to explore OSS popularity as a metric of OSS performance. However, the notion of popularity and success are often confused in the literature, we thus propose to first refer to literature of OSS success and its determinants in order to better understand the notion of success and the related limitations. Then, we will develop the notion of OSS popularity, explaining why we rather use this performance metric in our study.

II.1. Key determinants of OSS success

The success of OSS projects has become a critical topic with the growing OSS products usage by private and government organizations (Sen, 2007). In their taxonomy of OSS research, Aksulu and Wade (2010) group together performance metrics and identify quality and success as the two major metrics used to measure OSS performance. Software quality generally refers to OSS features such as usability, feasibility or adaptability and their impact on OSS adoption and diffusion (e.g., Jørgensen, 2001; Yu et al., 2006), whereas studies on OSS success generally focus on factors affecting or encouraging the value of OSS (Aksulu & Wade, 2010).
A common way to examine OSS success is to link it to the IS success model developed by DeLone and McLean (1992, 2002, 2003), which includes six interrelated measures of success: system quality, information quality, use, user satisfaction, individual impact, and organizational impact. However, these measures do not necessary take into account the unique characteristics of OSS -The development environment in which an OSS project evolves- (Crowston et al., 2003). To overcome these issues, previous studies analyzed different factors affecting projects success. In order to better understand these factors, we propose an ad hoc classification OSS system in which categories are used to summarize empirical observations related to OSS success (adapted from Webster and Watson, 2002). We proceeded as follow: first we divided our main concept – determinants of OSS success – into two subcategories, internal and external factors. Internal determinants of OSS success refer to factors directly related to the software itself, such as the type of license, the internal community or software quality, and their potential impacts on OSS success. Since OSS success also depends on external relationships that project members have with developers outside of the focal project (Singh et al., 2011), external factors refer to the impact of external interactions and interest level.
Internal as well as external factors that we highlight in table 1 have been demonstrated as drivers of OSS success. However, the definition of success has known different meanings across projects and stakeholders (Crowston et al., 2003), and previous studies commonly acknowledged that the success of OSS projects can be interpreted in different ways (Crowston and Scozzi, 2002; Capra et al., 2011). Grewal et al. (2006) explain that measuring success of OSS projects in terms of technical achievements or market success represents an incomplete picture of success. Several studies used the term popularity to examine OSS projects performance, consequently popularity can complete this picture as an indicator of OSS

success. One of these studies acknowledged OSS popularity as more relevant for less known project (Stewart et al. 2005) as it specifically focuses on users' interest.

Articles	Determinants of OSS success							
	Internal Factors				External Factors			
	OSS license	Software quality	Developers (skills, size, leadership, motivation)	OSS norms & values	Community service quality	Network	Commercialization and Sponsorship	User interest & motivation
Bagozzi & Dholakia (2006)					×			×
Bonaccorsi & Rossi (2003, 2004)			×					×
Brabham, 2008								×
Comino et al. 2007	×	×	×					
Crowston & Scozzi, 2008	×	×			×			
Dahlander & Magnusson, 2005, 2008						×	×	
Grewal et al., 2006					×	×		
Lee et al., 2009		×			×			
Lerner & Tirole, 2005	×						×	×
Meissonier et al., 2010			×					
Mendez & Garcia 2009						×		
Peng et al., 2013						×		
Sarker & Schneider, 2009			×					
Sen et al. (2007,2012)	×							×
Shah, 2006			×					×
Stewart & Gosain 2006				×	×			
Stewart, et al., 2006	×	×					×	×
Subramaniam et al. 2009	×		×			×		
von Krogh & von Hippel, 2006								×

Table 1: Antecedents of OSS success

Hence, rather than explaining success of OSS, we focus on OSS popularity as an outcome of OSS performance. In the next section, we develop the notion of popularity.

II.2. The notion of OSS popularity

Stewart et al. (2005, 2006) found that popularity is related to one measure of OSS success and define it as the level of interest and attention that the project generates among current and potential users (Stewart et al., 2005; Crowston et al., 2012). This parameter is crucial to estimate a project potential, as it is an indicator of how the community (users as well as developer) is judging a project (Capra et al., 2011). Thus, OSS popularity is considered as a key success factors for OSS project, as it evaluates extent to which an OSS project is able to attract community interest to the project software (Ghapanchi, 2009; Subramaniam et al., 2011). This indicator is particularly relevant for less-well known project, because it allows decision-makers to revaluate, adjust or rectify how to lead the project as it directly reflects the current level of interest. Moreover, it is much easier to gather data on popularity factors such as user and developer interest due to the openness of the development environment (Ghapanchi, 2009). As a result, academics started to investigate antecedents of OSS popularity to better understand why a project becomes successful or not. We summarize empirical observations related to OSS popularity using an ad hoc classification (adapted from Webster and Watson, 2002) as we proceeded for OSS success factor. We use external and internal factors as well in order to classify OSS popularity determinants (Table 2).

Articles	Determinants of OSS popularity					
	Internal Factors			External Factors		
	OSS license	Firm Involvement	Project Status	Developer support	User network	Sponsorship
Capra et al. (2012)		×				
Ghosh et al. (2013)				×		
Sen (2006)	×		×			
Stewart & Ammeter (2002)	×		×			×
Stewart et al. (2005)	×					
Sutanto et al. (2014)					×	

Table 2: Antecedents of OSS Popularity

When comparing OSS success and OSS popularity factors, the first observation that we can make is that there are much less studies that investigate the notion of OSS popularity, then the one examining OSS success factors. Second, and as argued by Ghapanchi et al., (2009), a review of these prior studies has identified that there is a lack of literature exploring the software development process considerations that predict user interest in an OSS project (Conley, 2008).

Third, Crowston et al. (2003) explain that the development environment in which evolves an OSS project requires taking into account this specific characteristic. Thus, the authors identify three measures more representative of OSS project performance: project activity level, development/team community and time taken to fix bugs. More specifically, Crowston et al. (2003) argue that rather than measuring the actual use, particularities of OSS project require measures of input (level of activities), process (speed of bug fixing) and output (popularity). While previous research mainly explores isolated factor (cf. table 2) rather than exploring the development process that can explain popularity, we think that we need a deeper understanding of the process and of the OSS popularity output determinants.

We identify that while (1) success directly refers to the level of a project, popularity refers to the level of individual attraction (eg. Sutanto et al., 2014), and (2) less is known on the determinants of popularity (Crowston et al. 2003; Ghapanchi et al. 2009). In order to overcome these gaps in the literature, our study focus on the OSS development process, using popularity as an outcome. The next part explains variables we use as drivers of popularity to develop our hypotheses and research model.

II.3. Hypotheses and research model development

To understand OSS project popularity, we must consider why users would choose one software solution over another (Stewart et al., 2005). As suggested by Crowston et al. 2003, we build our model by following the overall OSS development process including input, process and output (figure 1).

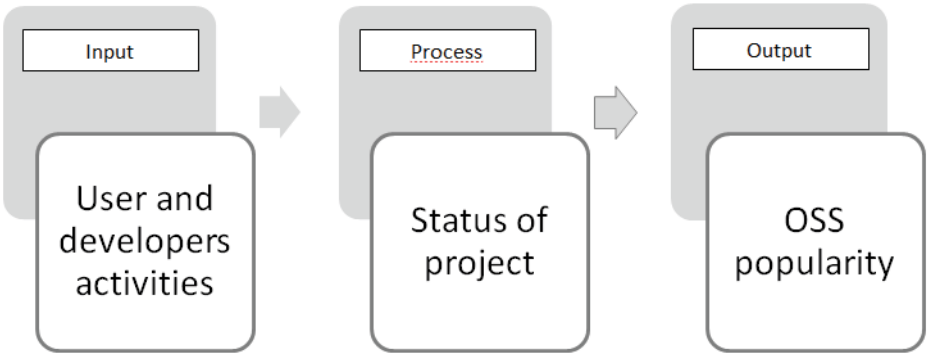

Figure 1: Development process of OSS project

First, the input considers the relationship between user and developers by using market-based measures. Indeed, successful OSS/technical support -OSS developer support- increases the fit of a project interest with OSS users which can increase OSS popularity (Ghosh et al., 2013). In order to provide a comprehensive view of OSS performance, we need to encompass both the developers' technical achievements as well as indicators of market success (Grewal et al., 2006). Thus, market potential can be examined as the right indicator of general project interest and market success (e.g., Grewal et al., 2006). OSS market potential can be explained by using network embeddedness theory (Sutanto et al., 2014), which suggests that potential users can be influenced by user support provided by the community regarding product use (voluntary contributions within an OSS community). Hence, when the number of queries increases, the number of visits on the OSS project website will increase (Singh et al., 2011; Sutanto et al., 2014), and consequently, the market potential of the OSS project will also rise, positively affecting positively its popularity. Second, in order to evaluate the notion of process, we consider the evolution of the project itself. Based on the IS literature, the project stage is likely to be a salient contingency factor that affects OSS project performance (e.g., Majchrzak et al., 2000; Qureshi & Vogel, 2001). Given the iterative process of an OSS project—owing to the interaction and re-adaption between developers and users based on users' needs—the development stage should also influence OSS popularity because more mature and stable OSS projects should have more views and downloads. However, many prior studies have used the development stage only as a control variable, not as a factor that influences OSS popularity (Stewart & Gosain, 2006; Singh et al., 2011; Sutanto et al., 2014). Third, the output includes the Studies on OSS popularity which have investigated the previous influencing factors separately; therefore, examining their combined effect will play a critical role in providing new knowledge on open source projects (e.g., Von Hippel & Von Krogh,

2003; Singh et al., 2011). Overall, as the effect of the user community (e.g., Dahlander & Magnusson, 2005; Toral et al., 2010) on OSS popularity depends on the combined effects of user-developer interaction (Wagstrom et al., 2005; Barcellini et al., 2008; Iivari, 2009); market potential, which signals the general interest level (Grewal et al., 2006); and development stage (Stewart & Gosain, 2006), this paper investigates user-developer interaction, market potential and development stage as antecedents of OSS popularity (figure 2).

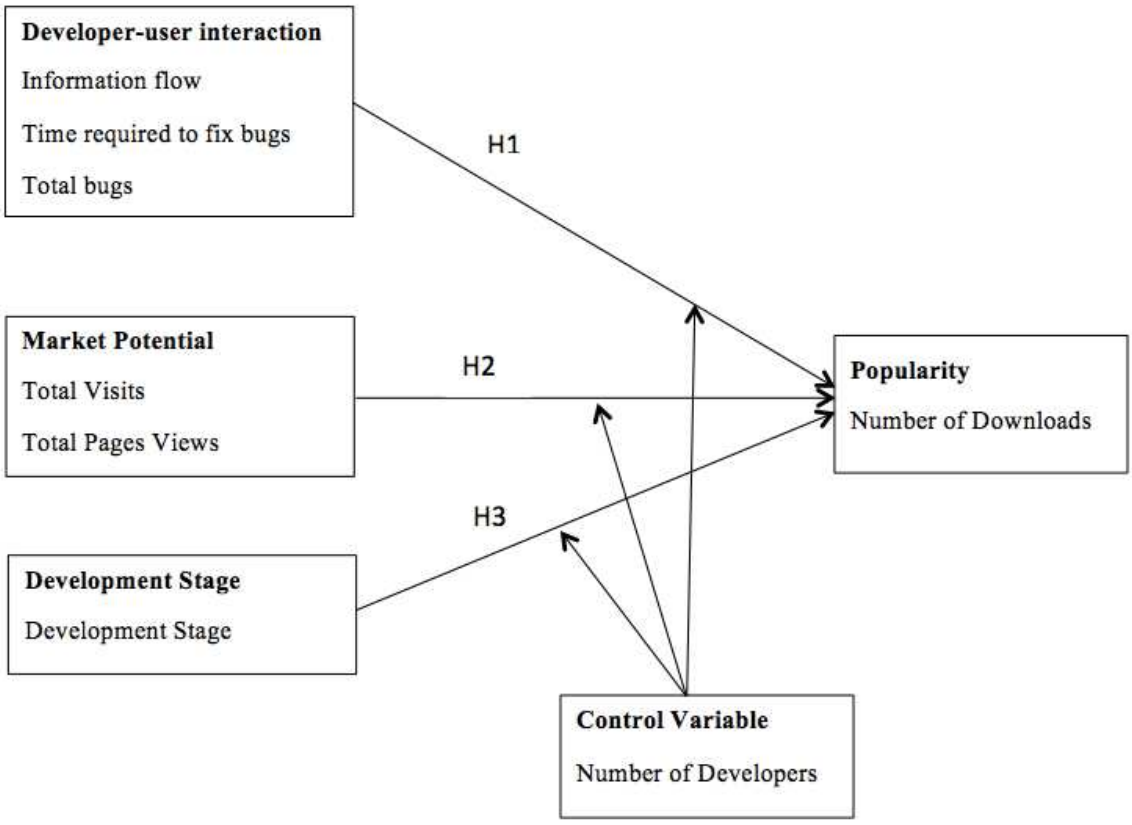

Figure 2. Conceptual Model

a. User-developer interactions

In order to explain the role of user-developer interaction in the context of OSS development, we rely on the phenomenon of mutual adaptation in the technology transfer process (Barton & Sinha, 1993). The process of transferring a technical system from developers to users always differs depending on the context (Barton & Sinha, 1993). Additional transformations and adaptations are required to fit the system to the operating environment. In other words, even if

the developers fit their system to their original technical objectives, they often have to readapt it during the project development process. During the development process, developers and users can exchange knowledge by jointly exploring the full potential of a new system.

Developers are defined as project team members who are directly registered on the project profile as developers who directly contribute to the project development. They are involved on different project activities, such as programming work, reviewing source code, detecting and fixing bugs (Ghanpanchi, 2013). They have a central role as they are the primary source of an OSS project emergence. However, previous studies in the OSS literature commonly recognize that users play a critical role in the evolution of open source products (e.g., Von Hippel & Von Krogh, 2003; Singh et al., 2011), as they strongly contribute to the modification and considerable improvement of such products. Numerous studies have developed measures based on user contributions to capture OSS project popularity. For example, user satisfaction, measured on the basis of users' interest in a project according to user ratings, user surveys or user opinions on mailing lists, is a commonly used measure of system performance (Crowston et al., 2003, 2006). Other measures focus on the development process, such as the level of activity users' contributions (Crowston et al., 2006). In this regard, user involvement has been found to positively affect OSS performance. Indeed, external resources are acquired from project members' relationships with developers outside the focal project, and the structure and type of these relationships affect outside developers' ability to transfer various types of knowledge that may affect the success of the focal project (Singh et al., 2011; Feller and Fitzgerald 2000). However, in the context of OSS, user involvement is hugely complex, since user involvement may be used only as a *buzzword or weapon for achieving solely managerial ends* (Iivari 2009a). In OSS context, user's role can be divided into two categories: *technical readers - non-technical readers which can act* respectively as consultative and participative, or only consultative (Iivari 2009a). Users are only consultative when their roles consist in comment on predefined design solution, while participative users actively participate in design process and are decision makers as well (Damodaran, 1996; Iivari, 2009a). More recently, Sutanto et al. (2014) similarly differentiated between active and passive users, explaining that active users provide answers to queries posted in the community discussion forum, while passive users are community members who either post only knowledge acquiring messages. The authors demonstrated that this effective online user support community is also necessary to foster OSS use and popularity by helping the OSS development and to influence positively or negatively the user community (Sutanto

et al., 2014). Particularly, it has been proved that users interest and involvement, as well as user's communication about an OSS project have a positive impact on OSS popularity (Ghapanchi, 2013). It thus clearly recognized that developers as well as users have both very identified roles in the OSS project development and have a considerable impact on OSS project performance. In other words, the interaction between users and developers can reinforce the mutual adaptation that occurs during project development to meet users' expectations. In order to better understand the role of both users and developers we argue that we need to deeply focus on the nature of interactions between them, and the impact on OSS project popularity. Based on prior research, we argue that user-developer interaction is an important factor that affects OSS popularity and therefore we propose the following hypodissertation:

H1: User-developer interaction during OSS development will positively influence OSS popularity.

To capture the level of the user-developer interactions, we focus on two elements. First, the OSS literature generally uses the exchange of information – Information flow- among these actors. Information flow represents the level of exchanges between co-workers, and allows leveraging the knowledge of other within the community (Sharma et al., 2002). Other studies have recognized that the flow of information among OSS members (developers and users), which is indicative of the level of interaction within the community, plays a critical role in the way in which problems are solved (Von Hippel & Von Krogh, 2003), bugs are fixed, patterns are identified and collaboration is carried out (Xu et al., 2007). Using social network analysis, academics have demonstrated that such communication among members has a positive impact on OSS success (Miralles et al., 2006; Wu et al., 2007; Stuermer et al., 2009; Iivari, 2010; Benkeltoum, 2013). In the context of our study, we argue that information flow is a valuable indicator of the level of interaction between users and developers with respect to its impact on OSS popularity. Thus, we posit the following hypodissertation:

H1a: Information flow among users and developers during OSS activities will positively influence OSS popularity.

Second, the OSS literature has examined "bug-related activities" in order to understand the role of OSS communities towards OSS success. More specifically, scholars have focused on whether OSS users and developers test new releases, submit bug reports, request features, and help others install, configure, and use the software (Zhang et al., 2013, Choi et al., 2015). Thus, examining activities related to fulfilling bug reports and feature requests might yield useful data regarding a project's status (Crowston et al., 2003). The number of bugs solved has been shown to influence the quality of software (Crowston et al., 2003; Sohn & Mok, 2008). For instance, academics have measured OSS project success by using bug-related activities such as the number of bugs fixed (Grewal et al., 2006), the time required to fix bugs (the ratio between fixed bugs and total bugs) (Crowston et al., 2006), and the number of bug reports (Lakhani & Von Hippel, 2003). This process of contributing to the code and fixing bugs has been demonstrated to be carried out in an iterative manner (Midha et al., 2010). Indeed, the effectiveness of the support community captures the interaction between users and developers, as user's activities are often represented by bug-reporting activities and a greater number of people working on the code will allow developers to find and fix bugs more quickly (Stewart & Gosain, 2006). Thus, we argue that bug-related activities constitute a good indicator of the quality of interaction among users and developers, which influences OSS popularity. Thus, we posit the following hypodissertation:

H1b: The time required to fix bugs during OSS development will positively influence OSS popularity.
H1c: The total number of bugs during OSS development will positively influence OSS popularity.

b. Market potential

The notion of market potential has been used as an indicator of general project interest (e.g., Grewal et al., 2006). OSS market potential can be explained by using network embeddedness theory (Sutanto et al., 2014), which suggests that potential users can be influenced by user support provided by the community regarding product use (voluntary contributions within an OSS community). As a result, a more active user community often improves perceptions of a project because of the resulting positive word of mouth (Van den Bulte & Lilien, 2001) wich generally increases the potential and viability of the project. Thus market potential represents the interest level of potential users for a particular project. While different factors can drive

the market potential of OSS projects, such as pressure from end users to increase social responsiveness of a program (Miralles et al., 2006), research has shown that active user-developer interaction may be able to mobilize other volunteers to respond to some of the user queries, which may increase a project's market potential and thus its popularity (Sutanto et al., 2014). Thus, we propose the following hypodissertation:

H2: High OSS market potential will have a positive impact on OSS popularity.

Project success varies with the number of page views (how many pages of each OSS projects have been visited) and number of visits (how many visitors have looked at the OSS project) as indicators of the market potential of a project, because the number of page views and visits directly signals the general interest level in the project and its market potential (Grewal et al., 2006). Hence, when the number of queries increases, the number of visits and page views on the OSS project website will increase (Singh et al., 2011; Sutanto et al., 2014), and consequently, the market potential of the OSS project will also rise, positively affecting its popularity. In other words, when there is positive word of mouth within the network of users, the number of page views and visits will increase (Van den Bulte & Lilien, 2001). In contrast, negative word of mouth would dissuade users from visiting the project website, thus lowering the number of page views and visits (Grewal et al., 2006). Consequently, the number of page views and the number visits are good indicators of market potential. This assumption allows us to propose the following hypodissertation:

H2a: Total visits will have a positive impact on OSS popularity.
H2b: Total page views will have a positive impact on OSS popularity.

c. Development stage

Recently, Sutanto et al. (2014) found that the development stage of an OSS project affects the number of downloads, which affects OSS popularity. In other words, various studies have shown that the number of downloads increases when OSS projects reach the production stage (i.e., the mature stage). Indeed, when a project is mature and advances to a later stage of development, the project is stable, and it can accumulate a greater number of important outcomes (user-developer interaction) that influence its popularity (Stewart & Gosain, 2006). As explained earlier, developers always need to improve their product so that they meet users'

expectations, account for market evolution and resolve bugs. Wynn (2004) found that the fit between the satisfaction and involvement of both developers and users during the life cycle stages of an OSS project constitutes an indicator of project success. In addition, Stewart and Gosain (2006) explain that both input and output measures of effectiveness are a function of development stage, because of the unpredictable utility of success in an earlier development stage. As we want to analyse the development process that lead to popularity (including input, process and output), we need to take into account the potential evolution through different stages of development, and the impact on popularity.
We thus investigate the following hypodissertation:

H3: The maturity of an OSS project with respect to its development stage will have a positive impact on OSS popularity.

d. Number of developers

Stewart and Gosain (2006) examined the effect of the number of developers on a project on OSS project success. We thus included the number of developers in our hypodissertation testing because an OSS project with more developers may be downloaded more often (Sutanto et al., 2014). Controlling for the number of developer on each project allowed us to account for the level of human capital actively involved in a project (Singh et al., 2011).

III. DATA AND RESEARCH METHODS

We collected data from 657 OSS projects in the SourceForge database. We decided to use one specific category of OSS projects, namely, enterprise applications that were exclusively hosted by the SourceForge website. The subcategory of enterprise applications concerned includes CRM (22%), ERP (33%), business intelligence (17%), data warehousing (15%) and workflow (13%) projects.

Development stage

We verified that all these OSS projects were less mature projects; thus, for each category, we excluded project such as open bravo and Sugar CRM.

User-developers interaction

As explained in the section II.3 Hypdissertation and research model development, bugs related activities are a key factor to capture user-developer interactions. We collected data from all projects with related forums where we could collect data on time required to fix bugs and total bugs. In addition, forums allow us to evaluate the information flow by analysing frequency of interactions

	Variables	**Measures**
OSS Project Characteristics	Popularity	Number of downloads
	Market potential	Total visits
		Total page views
	Developer-user interaction	Information flow
		Total bugs
		Time required to fix bugs
	Development stage	Development stage
	Number of developers	Number of developers

Table 1: Variables of OSS project popularity

We decided to use PLS regression not only for structural equation modelling but also as a specific regression method for applied management (Tenenhaus, 1998) that allows an independent analysis of the variables that can explain OSS project popularity. We used PLS regression mainly to overcome certain constraints of classical linear regression (Wold et al., 1983) and to allow us to simultaneously assess both structural and measurement models (Chin et al., 2003). In addition, the PLS regression method presents many advantages and yields good results not only when data are missing but also when there is collinearity between variables (Tenenhaus, 1998).

IV. RESULTS

We begin by analysing the correlation matrix that shows the potential relationships between the variables (Table 2). There is a significant and positive correlation between the total visits and all the other factors, where the coefficients range from 0.08 for total bugs to 0.47 for information flow. Concerning total page views, the correlations are positive and significant for three of the five factors but not significant for total bugs and time required to fix bugs. For information flow, we found that all the coefficients are positive and significant. Moreover, the variable total bugs is positively and significantly correlated with time required to fix bugs and development stage but not correlated with number of developers. However, we found a very strong link between time required to fix bugs and total bugs (0.98). Thus, we can conclude that collinearity is present between these variables. Regarding time required to fix bugs, the coefficient is significant and positive at 0.1 for development stage and non significant for number of developers. Finally, the number of developers is significantly and positively correlated with development stage (0.14).

	Total visits	**Total page views**	**Information flow**	**Total bugs**	**Time required to fix bugs**	**Number of developers**	**Development stage**
Total visits	1						
Total page views	0.317**	1					
Information flow	0.466**	0.196**	1				
Total bugs	0.08*	0.008	0.078*	1			
Time required to fix bugs	0.09*	0.016	0.094*	0.983**	1		
Number of developers	0.308**	0.169**	0.145**	0.050	0.046	1	
Development stage	0.277**	0.135**	0.127**	0.099*	0.100*	0.146**	1

**. Correlation is significant at the 0.01 level.

*. Correlation is significant at the 0.05 level.

Table 2: Correlation matrix

As mentioned above when we examined the correlation matrix, some variables are strongly correlated. To verify the presence of collinearity between these variables, we performed a multivariate regression to assess the collinearity statistics (tolerance and VIF). The results confirm the existence of collinearity between some variables (Table 3).

OSS project popularity (Download numbers)	Collinearity statistics	
	Tolerance	VIF
Total visits	0.65	1.53
Total page views	0.89	1.13
Information flow	0.77	1.29
Total bugs	0.03	29.12
Time required to fix Bugs	0.03	29.18
Development stage	0.91	1.10
Number of developers	0.89	1.12

Table 3: Collinearity statistics

As the results regarding the collinearity statistics in Table 3 show, collinearity is present for total bugs and time required to fix bugs. The tolerance for these variables is near zero (under 0.5), and the VIF is higher than two. To include all the observed variables and avoid excluding variables with collinearity, we incorporated them together in an efficient econometric model by using PLS regression. The expression of our model is as follows:

$$\log(Number\ of\ downloads+1) = \beta_1 + \beta_2 \log(Total\ visits+1) + \beta_3 \log(Total\ page\ views+1) + \beta_4 \log(Information\ flow+1) + \beta_5 \log(Total\ bugs+1) + \beta_6 \log(Time\ required\ to\ fix\ bugs+1) + \beta_7 \log(Development\ stage+1) + \beta_8 \log(Number\ of\ Developers+1) + \varepsilon$$

Hereafter, we verify the validity of the PLS regression over all the independent variables X_i (total visits, total page views, information flow, total bugs, time required to fix bugs, development stage, number of developers) and the dependent variable Y (OSS project

popularity—i.e., number of downloads). The objective of our analysis is to test the existence of a causal link between OSS popularity, market potential, developer-user interaction, development stage and number of developers (a control variable) in order to assess OSS performance.

The quality of the model is influenced by the tradeoff between the PLS regression with the collected data. The quality of the model is confirmed, and the model with the original variables is considered a satisfactory when $R^2Y(cum)$ and $Q^2(cum)$ are ≥ 0.5 (Tenenhaus, 1998). In final Model *4*, *which includes our complete research model*, 61% of the variance in OSS project popularity is explained by the number of OSS projects downloaded ($R^2Y(cum)$ = 0.61). We thus obtain a model with two axes that can predict 61% of the popularity variance, ($Q^2(cum)$ = 0.61), and we can interpret that the phenomenon explaining *Y* is well framed by *h* axes (named component) $t_1, t_2, \ldots, t_h$ if $Q^2(cum) \geq 0.5$. The application of this rule allows us to obtain a satisfactory model with the original variables.

For Model 4, we determine the significance of the PLS components on the axes by estimating the weight of each variable. The weight of each variable (X_i) constructing one axis is named W_i*c, where the weight of each variable is named W_i*c(1) for axis 1 and W_i*c(2) for axis 2. The proportion of the variance of independent variables X_i and dependent variable Y explained by the first axis t_1 is 55.2% for variables X_i and 59.7% for Y. The second axis t_2, in turn, accounts for 12.8% and 1.74% of the variance of independent variables X_i and dependent variable Y, respectively. Hence, the first axis better explains the variance in the model. The results are presented in Table 4:

Variables	$W_i^{*c(1)}$	$W_i^{*c(2)}$
Total visits	**0.474**	0.020
Total page views	**0.456**	-0.063
Information flow	0.345	**0.692**
Total bugs	0.228	-0.198
Time required to fix bugs	0.193	**-0.447**
Development stage	**0.486**	0.285
Number of developers	0.346	**-0.452**
Popularity (Y)	0.394	0.161

Table 4: Weight of variables

The importance of the axes can be determined by estimating the weights of the independent variables based on the construction of the axes from running the PLS regression. Axis t_h better maintains the factors in X_i and still has sufficient ability to predict Y (OSS project popularity). We note that market potential, measured by "total visits" and "total page views", and development stage highly contribute to the first axis. Of course, the other variables also contribute to the first axis. Further, the second axis is mainly influenced by developer-user interaction, as measured by "information flow" and "time required to fix bugs". However, we observe that these variables have opposite effects. The variable number of developers also contributes to the construction of axis 2. We note the existence of a relationship between "total visits", "total page views", "information flow", "development stage" and "OSS project popularity". Thus, the following variables have a significant causal link with OSS project popularity: "market potential", "developer-user interaction" and "information flow".

As the results presented in Table 5 show, the VIP (very important variables) indicate that all the variables contribute to the phenomenon studied. In particular, the results reveal that three factors—market potential, developer-user interaction (only for information flow) and

development stage—have a positive and significant influence on OSS project popularity. The results specifically show that development stage, information flow (capturing developer-user interaction), total visits and total page views (both of which capturing market potential) explain 24%, 25%, 19% and 17%, respectively, of OSS project popularity.

			Model 1		*Model 2*		*Model 3*		*Model 4*	
		Variables	*VIP*	*Coef*	*VIP*	*Coef*	*VIP*	*Coef*	*VIP*	*Coef*
OSS Projects Characteristics	**Number of developers**	Number of developers	*1*	*0.167*	*1.18*	*0.38*	*0.97*	*0.13*	*0.92*	*0.064*
	Market potential	Total visits					*1.32*	*0.28*	*1.24*	*0.19*
		Total page views					*1.26*	*0.26*	*1.19*	*0.17*
	Developer-user interaction	Information flow			*1.15*	*0.34*	*0.96*	*0.21*	*0.95*	*0.25*
		Total bugs			*0.91*	*ns*	*0.65*	*ns*	*0.60*	*ns*
		Time required to fix Bugs			*0.86*	*ns*	*0.59*	*ns*	*0.54*	*ns*
	Development stage	Development stage							*1.27*	*0.24*
			N = 657		**N = 657**		**N = 657**		**N = 657**	
			$R^2Y = 0.03$		**$R^2Y = 0.43$**		**$R^2Y = 0.59$**		**$R^2Y = 0.61$**	

*VIP = Importance of the independent variables in explaining OSS project popularity

*Coef = Weight of the regression coefficient for the dependent variable

**Sign 0.05 (5%)*

Table 5: Weight of the independent variables of the PLS regression

To further analyze the impact of the development stage on OSS popularity and complete our understanding of our research model, we divided the sample of OSS projects based on development stage, with values between 1 and 3 denoting younger project and those between 4 and 7 denoting more advanced projects. We then reapplied the PLS regression to a new

model, defined as Model 5, that included the same variables as Model 4 but used two different samples (younger projects and more advanced projects in terms of development). According to the results of Model 5, the R^2Y was 0.36 for younger projects and 0.77 for more advanced projects, where the difference was significant at $p < 0.05$. Hence, our model better explains OSS popularity for more advanced projects than for younger projects. Specifically, we can explain OSS popularity with a delta of 16% for more advanced projects based on the development stage.

We have assessed our model by using a PLS regression model applied to the 657 projects from which we collected data (i.e., enterprise applications). The analysis of OSS project popularity is based on the number of developers, market potential, developer-user interaction, and development stage, and the analysis shows that the number of developers has a very small, significant, positive effect on the popularity of OSS projects (*0.064)*, (cf Table 5). We consider this effect to be negligible. Moreover, the effect of market potential (total visits and total page views) is significant ((*0.19* and *0.17*, respectively*)*. Thus, these variables positively influence OSS project popularity, supporting Hypodissertation 2. Concerning developer-user interaction (information flow), the coefficient is significant at *0.25*, indicating that developer-user interaction positively influences OSS project popularity and partially supporting Hypodissertation 1 (i.e., H1a is supported). By contrast, H1b and H1c are not supported, as the coefficients for time required to fix bugs and total bugs are not significant. Finally, H3 is also supported, as the coefficient for development stage is significant at *0.24*, indicating that this variable positively and strongly influences OSS popularity. Thus, we can conclude that we have found support for most of our hypotheses related to our research questions, as our results show that OSS project popularity is explained by market potential, developer-user interaction, and development stage.

V. DISCUSSION

The present research addresses the following research questions: Does the combined effect of user-developer interaction and market potential lead to greater OSS popularity? Moreover, how does the development stage influence this combined effect on OSS popularity in less mature projects? To conduct this study, we investigated the combined effect of these three factors on OSS popularity. Our developed model was applied to data from a sample of 657 open source projects hosted by Sourceforge.net with a focus on the development of enterprise applications in less mature projects.

Based on our data analysis, we can conclude that OSS popularity is positively influenced by user-developer interaction, market potential and the development stage during OSS development. Consistent with the IT literature (Singh et al., 2011), our results show that extensive information exchange (information flow) among users and developers is optimal for knowledge sharing and is associated with greater OSS popularity. Nevertheless, the lack of significance for the effect of bug-related activities on OSS popularity is interesting and needs to be highlighted. Numerous studies have proposed the time taken to fix bugs as a measure for software quality (e.g., Kim et al., 2005) and demonstrated that the total number of bugs and the time required to fix bugs have significant effects of OSS success (e.g., Grewal et al., 2006). Our study showed that while information flow has a direct effect on OSS popularity, bug-related activities do not have a significant effect on OSS popularity. As OSS popularity is used to measure OSS success for less well-known projects (Crowston et al., 2012), our results interestingly reveal that in such a context, and in contrast to the existing literature, bug-related activities do not have an impact on OSS popularity and do not constitute a valuable measure for project popularity.

Further, to strengthen the measure of OSS popularity, market potential must be considered. Indeed, previous research has shown that OSS project success increases as the number of visits increases (Grewal et al., 2006), since positive word of mouth increases the number of users visits to webpages. Consistent with this finding, our results showed that the number of total visits increases with the number of total page views and significantly affects the number of downloads. Moreover, another interesting finding is that the effects of user-developer interaction and market potential on OSS popularity change as projects move through different development stages. This result corroborates previous research (e.g., Stewart & Gosain, 2006) showing that the development stage plays an important role in determining project popularity, particularly for more advanced projects. Our findings have some interesting implications for both theory and practice.

From a research perspective, academics have commonly recognized that the challenges involved in exploiting communal resources due to the particular OSS context lead many OSS firms to struggle for survival (Dahlander & Magnusson, 2005). Accordingly, numerous studies in the IT literature have aimed to explain OSS success by examining several variables separately. However, studies explaining OSS popularity focused on less mature projects remain limited, even if this topic is relevant. Our research highlights the combined effects of factors that influence OSS popularity in OSS projects.

First, the empirical results generally support the theoretical reasoning based on a social network perspective within the broader context of OSS user group participation rather than OSS development alone (e.g., Hars & Ou, 2002; Lakhani & Wolf, 2005; Bagozzi & Dholakia, 2006). Specifically, the level of information flow was shown to have a significant impact on OSS popularity, supporting our arguments that such interaction among user and developers increases users' interest in a project and thus the number of downloads. Moreover, the unexpected result of a less significant impact for bug-related activities is relevant within our reasoning. Indeed, the level of communication inside virtual communities is a more valuable measure for OSS popularity than the numbers of developers involved in the community in the specific case of less mature project. Our "counterintuitive" finding thus highlights new factors that should be used to measure OSS popularity.

Second, another contribution of our study is that we clarify the role of market potential in influencing OSS project popularity. As explained above, positive word of mouth seems to positively influence the success of a project, as it provides a positive signal for potential users. Specifically, the number of page views and number of visits are also valuable indicators for users that influence their interest to less mature projects, which directly affects the popularity of such projects (Gallego et al., 2008).

Third, the OSS literature contains numerous works that have used the development stage (or project age) as a control variable, since projects in earlier stages may be less certain to provide utility and may thus reduce motivations for input (e.g., Stewart & Gosain, 2006). The present research thus tested the direct impact of the development stage on OSS popularity. The obtained positive relation between OSS popularity and the development stage empirically indicates that the development stage of OSS projects is an important factor in measuring project popularity. This finding provides new theoretical insights regarding the factors that affect OSS popularity by highlighting a new factor that directly affects OSS popularity, especially for less mature project.

Furthermore, our findings have some implications for organizations that use and adopt OSS development practices. The number of firms using OSS has increased in the past several years, although the high failure rate is still significant. More important, firms are working on developing their own software, which often leads to the adoption of less mature projects for users (Khedhaouria & Ribiere, 2013). Research identifying the factors that influence OSS popularity can thus provide a preliminary understanding for organizations that want to better understand OSS development (Stewart & Gosain, 2006). In particular, our results indicate that

firms should pay attention to the development stage of an OSS project before deciding to internally implement a new OSS project. Indeed, the results indicate that the maturity of projects influences the number of downloads, indicating that organizations should take into account the project age in order to limit the risk of failure while implementing an OSS project. Past research explain that the number of downloads are relevant indicators of OSS projects success as it indicates the traffic on the project website (eg. Stewart et al 2005). However in our study, because we focused on less-mature projects, we used the numbers of downloads as an output. Indeed, this indicator represents a very relevant way to measure the popularity of a project, and thus evaluate the potential success. Because potential success depends on potential users, it might be useful for firms to better understand why users should be interested to use one project than another at a less mature stage of development, in order to adapt and readjust key elements during project evolution. Thus, beyond providing guidance on the aspects that influence OSS popularity, the results show that firms should focus on multiple factors to avoid failure. Substantial attention has been devoted to increasing users' and developers' motivation to participate in a project (e.g., Meissonier et al., 2010) or attracting users and developers (e.g., Krishnamurthy, 2002). However, our study suggests that beyond the number of users or developers, the activities of these actors—that is, the level of information flow among users and developers—is directly related to OSS popularity. Firms should thus be aware that simply attracting developers may not ensure project success (Stewart & Gosain, 2006), and managers should focus on developing quality interactions among members in order to foster OSS popularity. In addition, the number of pages viewed represents an important concern for firms, as it signals the general level of interest for a project. This measure of market potential for an OSS project should thus represent a valuable indicator of OSS popularity that firms may take into account during OSS development or decision-making.

VI. CONCLUSION

This research investigated the factors that affect OSS popularity in the context of less mature projects. The results revealed that user-developer interaction and market potential have a positive impact on OSS popularity. However, in contrast to previous OSS studies, information flow among users and developers has a stronger influence on OSS popularity than bug-related activities. The findings further highlight that our model is more significant with respect to advanced projects, demonstrating the importance of project development in explaining OSS

popularity. Nevertheless, our research has some limitations that provide avenues for future research.

First, a main limitation of our research relates the variables we used in our model. Specifically, we investigated the combined effect of user-developer interaction, market potential and development stage on OSS popularity, and we controlled for the number of developers; however, we did not control for community size and project category. This limitation should be overcome in future research, as previous studies have suggested that these factors have a significance influence on OSS popularity (Sutanto et al., 2014).

Second, our model is not appropriate for determining the influence of individual factors on OSS popularity. Numerous studies have relied on individual factors that lead to the emergence of projects leaders within an OSS community and have linked these skills to OSS success (e.g., Lerner & Tirole, 2001; Giuri et al., 2008). It would be useful for future research to apply and transpose these individual factors to our model in order to increase our understanding of OSS popularity.

Third, this study focused on less mature project in order to evaluate the factors that affect OSS popularity (Crowston et al., 2012), whereas previous research in the OSS literature has used the notion of success to evaluate the quality of well-known projects. However, some recent research has assumed that the interrelationships among different success indicators of OSS projects are not well understood in the literature (Ghapanchi, 2015). Accordingly, it would be useful to replicate the analysis in this study on more well-known projects in order to provide a better understanding of general measures of OSS quality.

Despite these limitations, our research provides some interesting implications for both theory and practice. In particular, we reveal some unexpected patterns that add to our understanding of why certain OSS projects are popular by employing a novel perspective that combines factors that affect OSS popularity. Our results should thus encourage researchers studying open source systems to adopt a perspective that more integrates success and popularity factors in order to increase knowledge on OSS as a part of innovation strategy (Teigland et al., 2014).

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Article 3

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FORMULATE OR NOT FORMULATE: SOLVING PROBLEM WITH A DYNAMIC CAPABILITIES PERSPECTIVE

CLEMENCE CHERUY
Montpellier University

NASSIM BELBALY
Montpellier Business School

GEORG VON KROGH
ETH Zurich

BURCU KÜCÜKKELES
ETH Zurich

When company decides to outsource a problem, it expects to meet the optimal solutions from external solvers. However, usually firms struggle first on how to perform the right problem solving process to generate the best ideas. Second, when they figure out which strategy to follow, they still have hard time to decide if they are going to formulate or not. Our research, designed on a crowdsourcing context, explores this question by drawing on the dynamic capabilities perspective applied to both problem formulation and need solution pairs. The dynamicity and complementarity between these two processes uses the evolutionary theory of ideas to optimize the search of solutions.

Introduction

When companies face a problem, they have to engage into a problem-solving process in order to define and search for a large number of creative and cost-effective ideas which should become implemented solutions in a timely manner (Sheremata, 2000). In other words, companies have to make strategic choices in order to first, choose the most effective manner to pose the problem, and second, to choose between an alternative of solutions to catch the most effective one.

Numerous studies have examined how to enhance problem-solving effectiveness. It has been proved that solution quality is a function of several intra/extra organizational conditions. For example, at the individual level, scholars have demonstrated that problem-solving performance depends on solution seekers characteristics - the expertise or knowledge level- (e.g. Afuah and Tucci, 2012; Becke, Salvatore, Zirpoli, 2005). At the organizational level, effectiveness of the solution largely depends on different factors as for example open or closed governance (e.g. Fein and Zenger, 2014) or the use of virtual tools (e.g. Becke, Salvatore, Zirpoli, 2005).

Although problem-solving phenomenon has been well studied in its overall process, optimization of the idea generation process to find the most innovative and adapted solution to the problem faced has rarely been explored. In fact, the problem-solving process approach has been theorized as a succession of steps composing the overall process, which are problem identification (Spradlin, 2012), problem formulation (Simon, 1973; Volkema, 1983; 1986; Lyles and Thomas, 1988) and problem-finding (search for solutions) (Lang et al. 1978). In order to optimize the solutions search, researchers provide a proliferation of studies on these different steps, showing that they have a strong impact on solution quality.

Moreover, many studies have consider problem formulation (PF) as the critical first stage of problem solving, by which alternatives views of a problem are generated and selected to build the formulation of a problem (Lyles and Mitroff, 1980). The main difficulty of formulating the problem has been brought out by Simon (1977) who drew a crucial distinction between well-structured and ill-structured problems, explaining that only well-structured problems were suitable for algorithmic solution. Although organizational research worked on convert ill-structured to well-structured problem to optimize the search of solutions, scholars demonstrated that problem reformulation can affect problem solving process in transmitting

inaccurate or incomplete information to problem solvers (Simon, 1977; Von Hippel & Tyre, 1995; Von Hippel & Von Krogh, 2013).

In order to overcome these problem formulation limits, additional recent research have tried to solve problem without problem formulation (Von Hippel and Von Krogh, 2013). Indeed, the authors have noted, that in informal problem solving process, a need and a solution are often discovered together and argued that the discovery of a viable need-solution pairs (NSP) may have advantages over problem solving/initiated methods, and provide more innovative solutions under certain circumstances (Von Hippel & Von Krogh, 2013). Even if this method seems to overcome the difficulties of problem formulation, the authors precise that scholars have to learn how it works and can work in different context and governance and induce that academics must conduct research to understand the principles associated with its functioning. Indeed, today there are no existing studies to support nor the theory or practice of problem solving via identification of need solutions pairs (Von Hippel and Von Krogh, 2013). In this paper, we argue that these two alternatives are not opposite, but rather complement one other.

However, in order to better understand the open problem-solving process, we consider the idea as the unit of analysis to be able the idea progression process during the idea generation on the crowdsourcing platform. In this research, we build on idea evolutionary theories in order to explain how variations among individuals make the process iterative, between the search and solutions landscapes, and thus between NSP and PF. In addition, even if the iteration process is inevitable to understand idea elaboration for problem solving, it does not necessary explain the search for optimal solutions. According to Staw (1990) view of ideas evolution, ideas entail a dynamic transition during the elaboration phase. Building on this idea, we integrate the dynamic capabilities perspectives in order to explain how to catch most valuable solutions through the problem solving process. The next section is dedicated to explain this process.

Dynamic Problem-Solving Process

Since several years, it has been proved that firms can choose to externalize problem-solving process by inviting the participation of external solvers (e.g. Jeppensen and Lakhani, 2010). As a result, an increasing number of firms use crowdsourcing techniques in order to catch innovative solutions from the crowd, and it has been demonstrated that the seeker can benefit from a larger solver population because it obtains more diverse solutions, depending on the

award structure (Terwiesch and Xu, 2008). In their recent research, Afuah and Tucci (2012) demonstrated that crowdsourcing the problem can be a more valuable solution for firms when they develop the adequate circumstances to succeed. However, there is a lack of knowledge on how to promote solutions innovativeness, and more specifically, the idea generation process still have limited insights with regard to the "ideal" process (Poetz and Schreir, 2012). In others words, scholars need to understand how innovative ideas are generated or elaborated in a context of open call and how external problem-solving process works to solve problems.

Hence, when a company decides to outsource a problem, managers inside firms have first to formulate the problem and then to put it into the crowd. However, they have two alternatives: either they can formulate the problem through problem formulation process, or they decide to not formulate the problem and use the need-solution pair's process. In order to perform these two problem-solving approaches, imagine the example of two open call challenges on tactile tablet product, using an idea generation platform. The first one follows the problem formulation approach in precisely formulating the problem to the crowd: *How to improve tactile tablet. To answer the challenge, you have to reflect on the following criteria: Memory, Weight, Features, Battery, Connectivity, Touch Screen and Design*. Thus, participants have to follow precise instructions. The second is formulated in a reverse manner, with the willingness to not formulate the problem, but rather to invite the crowd to reflect largely among strong interactions within participants. Thus, we asked participant to *Invent the next tablet generation,* as proposed by NSP theory.

In order to better understand the open problem-solving process, we have to consider the idea as the unit of analysis to be able the idea progression process during the idea generation on the crowdsourcing platform. According to Csikszentmihalyi (1997), the creative process is described in five steps. The first one is idea *preparation*, when the individual becomes immersed in a problematic issue. After, comes the *incubation* and *insight* phases – the individual processes information and new ideas begin to emerge. Then, the idea evaluation phase is associated with the act for the individual to decide if the ideas are valuable or not. Finally, the last step is the *idea elaboration* one – the individual pursue the new idea by transforming, developing and refining it (Mainemelis, 2012). This last step is the starting point of our approach to define and explain the idea progression process. Indeed, it has been proved that once an idea has been selected by the creator, developed, and communicated, there is often a second selection process by relevant individuals in a social group or intellectual community (Amabile & al., 2005), and during these steps, new problems or

insights arise out of these interactions. This view is consistent with the evolution literature, as demonstrated by Campbell (1960), who explained creativity with his model of blind-variation and selective-retention, showing that creativity implies a set of elaboration on nascent ideas (Campbell, 1960; Csikszentmihalyi, 1997; Mainemelis, 2002; 2010). A consistent body of literature applied the Darwinian creative process to creativity and problem solving research (Simonton, 1999). Therefore, following evolutionary theory of creativity (Staw, 1990), and idea elaboration theory (Csikszentmihalyi, 1997), it seems that the idea follow an iterative process among different set of variations, until the emergence of the optimal solution. Thus, we posit that idea generation platforms represent a context that allow and facilitate variations between individuals (participants).

To better understand the idea progression in real crowdsourcing setting, we return to the example of open challenge on tactile tablet via idea generation platform. If the company decides to use the problem formulation approach, participants are confronted with precise instructions to solve a problem. Ideas among participants are emerging and be posted on the platform following the instructions. When participants see ideas of others, they can comment, like, vote, and even improve ideas of each other. These interactions between participants make the ideas progress and develop. This variation phenomenon is the concrete representation of idea elaboration phase, in a crowdsourcing context. On the other side, if a company follows the NSP approach to introduce a problem to the crowd, participants do not have to follow any instruction and are free to post ideas on any tablet aspects. However, when ideas emerge, interactions among participants (comments, votes and likes) encourage individuals to self-formulate the problem in order to obtain necessary information on others ideas and reformulate them. Consequently, the problem-solving process through an ideation platform follows an iterative idea evolution process that build on the ideas variation among participants that go from problem formulation to need solution pair and vice versa. Thus, in a crowdsourcing platform context, the problem formulation process and need solution pairs process are not in competition but they are complementary. It the integration and combination of both approaches that support efficiently the problem solving process that aim to find the best solution to the problem faced.

Even if numerous studies have worked to understand how to enhance users innovativeness (e.g. Terwiesch and Xu, 2008), the process of generating the best idea within a crowdsourcing platform still remain little explored. Indeed, even if the iteration process is inevitable to understand idea elaboration for problem solving, it does not necessary explain the search for

optimal solutions. As a result, we propose to focus our study on how to explain the search of the optimal solution process. In order to provide consistent insights on this issue, we build on Staw (1990; 1995) evolutionary of creativity. This author has demonstrated that evolution of new ideas entails a dynamic transition where ideas are evolving and refining until the optimal one (Staw, 1990; 1995). Nowadays the notion of dynamicity is integrated by firms who develop specific skills to integrate external knowledge inside the company in a successful way (Lichtenthaler and Lichtenthaler, 2009; Gassmann and Enkel, 2004; Ridder, 2011). To support this assertion, Lichtenthaler and Lichtenthaler (2009) provided a capability-based framework of open innovation, demonstrating that 'Knowledge management capacity' is a dynamic capability, which reconfigures and realigns the firm's knowledge capacities. Teece (2007), conceptualized three classes of dynamic capabilities (DCs) on the most comprehensive level. Firms exhibiting strong DCs effectively *sense and shape* opportunities, address these opportunities by *seizing* them, and continuously *reconfigure* themselves as markets and technologies change (Teece, 2007). As a result, we argue that idea elaboration process has to be couple with a DCs approach in order to optimize the search of optimal solution in problem-solving process (figure 1).

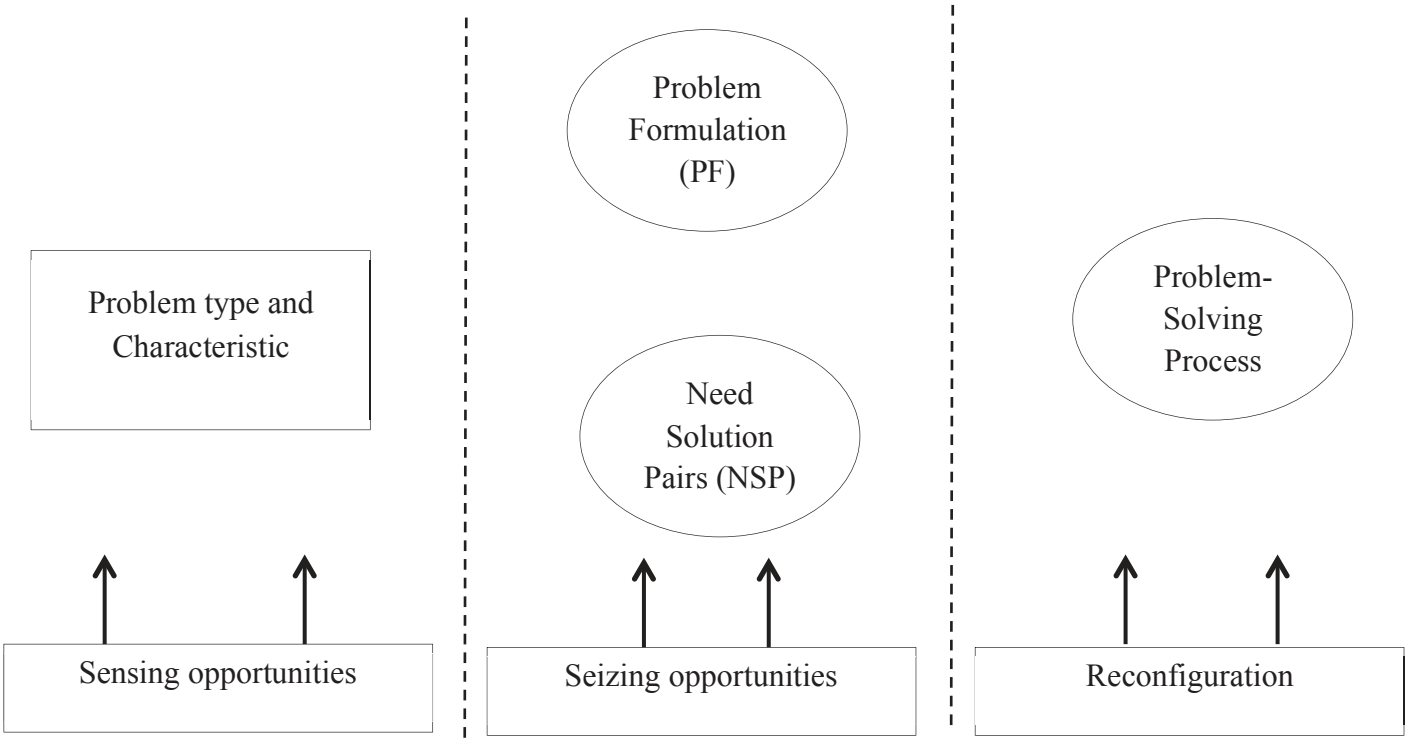

Figure 1: Dynamic capabilities approach to problem-solving

Based on Teece's (2007) view of dynamic capabilities, we describe the different process steps. Sensing characteristics (1), refer to the evaluation of problem type and characteristics. Indeed, when a company decides to crowdsource a problem, managers have to evaluate different problem characteristics (Afuah and Tucci, 2012), which could have an influence on how to introduce the problem to the crowd. First, they have to evaluate if the problem in well or ill-structured. Second, they have to assess if the expected solution has to be ether radical or incremental according to the problem type. And third, in function of the desired solution, is the company more expecting to address for an expert audience or either to mass population. Depending on the mentioned characteristics, seizing alternatives (2) refer to choose the best alternatives to initiate problems to the crowd. In other words, managers have to evaluate either they have to formulate the problem following problem formulation approach or a NSP approach. Finally, reconfiguring (3) refer to the idea elaboration phase, in which the ideas follow variations and dynamic iteration between participants, until finding the optimal solution to the problem faced. In the next section, we develop the three steps of dynamic problem-solving process and explain each step in context of PF and NSP.

Problem-solving Process Evolution

This study is designed around the overall problem solving process. Research and discussion of problem solving can be partitioned conveniently into three levels of complexity, depending upon who is involved in the problem solving (Lang et al. 1978): Individual level, group level and organizational level. For each level, numerous authors have explored the overall problem solving process. In this section, we transpose classical literature on problem-solving to the ideation context of our study, in order to demonstrate the iteration between the three analysis levels and the evolution of the process.

At the individual level most models describe a cyclical model following the notion of feedback. All seem to account for problem finding, choice, and action behaviors with varying degrees of precision, ranging from the simple models suggested by Norton, Custafson and Foster (1977) to more complex systemic models of Newell and Simon (1972) (Lang et al. 1978). Following this idea, Maier (1964) introduced the idea evaluation process to explain the idea progression within individual. At the group level, numerous methods have been studied in order to improve creative idea generation by group of people, such as brainstorming, Nominal Group Technique or Delphi procedure (for review see Rickards, 1980; Delbecq et

al., 1975). These methods have been demonstrated to enhance creativity during the idea generation process. Concerning the organizational level, problem solving process is more complex because it depends on resources available (Lang et al. 1978). These resources and their impact have been largely studied in the literature in order to understand the link with problem solving process. Appleyard et al. (2006) explored how HR system and knowledge system affect problem solving performance. They found that externally oriented HR and knowledge system are associated with superior performance in terms of problem-solving speed. Another example is the research of Felin and Zenger (2014), who explored the impact of open or closed governance choice on problem solving effectiveness. They found that certain types of innovation problems are best addressed by certain types of governance forms, whether open or closed. Thus the optimal governance of innovation is contingent on the nature of the innovation problem to be solved. Other authors showed that culture (Bate, 1984), centrifugal (eg. decentralization) and centripetal forces (eg. connectedness) (Kwaku, 2003) can impact the overall problem solving performance. Thus, it appears that the opening of problem-solving process can be valuable for the search of more innovative solutions (Hienerth et al, 2014). In addition, Becker et al. (2005) explored the potential of virtual simulation tools for improving problem-solving performance. They found that virtual tools lower the cost and increase the speed of testing solutions in the set of possible solutions, because it enables testing a higher number of alternatives and a higher speed of testing allows testing a higher number of alternatives in the same period. Thus, we think pertinent to transpose the overall problem-solving process to the crowdsourcing context of our research. In this context, we hence analyze the three levels of problem-solving process. At the **organizational level**, managers identify the problem before to turn it outside. If we come back to the ideation platform example, when the problem enters to the crowd, individuals are going to reflect on the problem through the ideas variations process, at **the individual level**. And then, interactions among participants lead the problem at a **group level** problem analyze.

A Dynamic Capabilities based model of Idea Evolution

In the field of open innovation (Chesbrough, 2003; von Hippel, 2005, Terwiesch and Xu, 2008), it has been well documented that users than manufacturers can be a more valuable source of product development in numerous industries (see Von Hippel, 2005). And more specifically, it has been proved the users ideas generated in a context of crowdsourcing might also hold commercial potential (Ogawa and Piller, 2006; Potz and Schreier, 2012).

A more recent stream of research is to identify the question of value capture in crowdsourcing tasks, because the main reason to outsource the problem is based on the expected value (benefits to customers) of the solution and/or cost of offering the benefits (Afuah and Tucci, 2013). In their article, Afuah and Tucci (2012) describe how the probability of a firm's use of crowdsourcing is influenced by a variety of factors. However, they do not establish the ability of the solution to capture the value it creates (Bloodgood, 2013). The value capture is fundamental to a firm, because it allows gaining and sustaining competitive advantage, which is particularly pertinent when firms open boundaries. Indeed, competitors are less likely to know how a focal firm achieved its success when the problems the focal firm faced are not even known. Thus, solving the problem is not the end goal because the problem is solved for others as well (Bloodgood, 2013). In other words, when companies search for external solution, they must concentrate effort on searching for value capture, the optimal solution, to gain competitive advantage from competitors. We argue that this observation is fully pertinent with the dynamic capabilities perceptive that we discuss before (e.g. Teece, 2007). Thereby, we argue that integrating Dynamic Capabilities for distant search problem-solving is a possible way to exploit the *value of crowdsourcing*. In this section, we discuss the whole problem-solving process, including evolutionary and dynamic perspectives (figure 2).

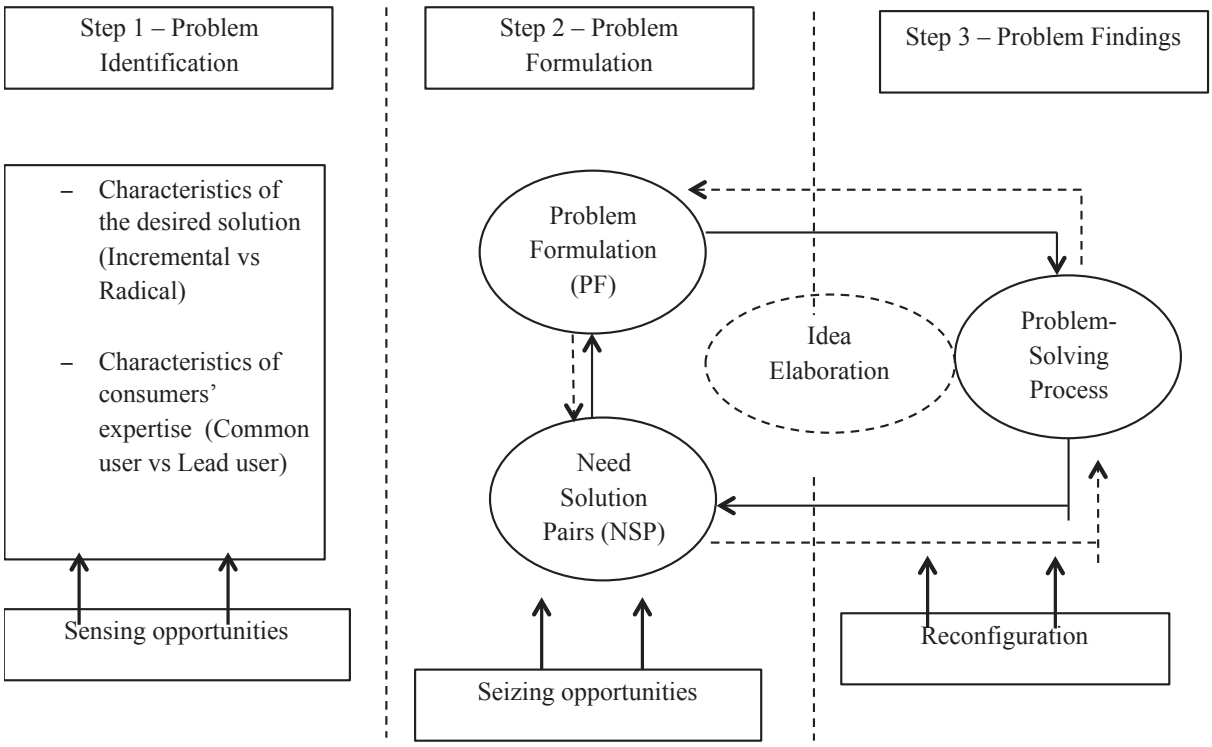

Figure 2: Problem-Solving process: A Dynamic Capabilities based model of Idea Evolution

1. Sensing opportunities: define and identify the problem

In a dynamic capabilities perspective, when opportunities are glimpsed, firms need to gather and filter technological, market, and competitive information to figure out implications for action (Teece, 2007). Teece (2007) define sensing opportunies as search for potential knowledge sources or customers, while simultaneously monitoring and identifying internal needs and requirements. It is admitted that before formulating the problem, problem solver have to first identify the problem to be solved as the main issue for companies is *to not answer* to "the wrong problem" (eg. Spradlin, 2012). Nelson and Winter (1982) define a firm's knowledge (or capability) as the "input-output combinations achievable with all possible mixes and levels of activities known to the firm" (pp. 63–64). In this literature, the state of a firm's knowledge can be advanced by either absorbing existing knowledge external to the firm first identifying a problem and then discovering a valuable new solution (Nickerson and Zenger, 2004). Thus, the choice of problems reflects an assessment of the expected value of potential solutions and an assessment of the firm's capacity to profitably reach high-value solutions (Nickerson and Zenger, 2004). Therefore, identify the problem is

the critical first stage of dynamic problem solving, referring to the act of sensing problems characteristics. As a result, managers have to take into account two different characteristics: the desired solution **(radical vs incremental),** and relevant knowledge (**common vs expert knowledge**) to the probability of discovering a high-value solution. We next explain these characteristics.

First, as explained by Von Hippel and Von Krogh (2013), experts or problem solvers have to identify the "underlying" problem to be solved and "realize that the troublesome manifestation may be only a symptom of a cause that lies deeper. In his research, Spradlin (2012) explains that company has to first define the need for a solution: *looking for lubricant for a piece of machinery is different from seeking a radically new manufacturing process.* In answering the question of what is the desired outcome, requires understanding the perspectives of whether they have to search for incremental rather than radical solutions.

Second, and according to the desired solution, company has to decide the target audience. Indeed, a consistent body of literature has theorized that problem-solving activities are associated with New Product development activities, and open source innovation has been used for many years as a strategy to enhance product development (Iansiti and Clark, 1993; Iansiti, 1995; McDonough and Barczak, 1992; Thomke, 1998a,b, 2001b; Verganti, 1997; Thomke and Fujimoto, 2000; West and Iansiti, 2003). Thus, concerning the audience, it has been demonstrated in the one hand, that due to an effect called "functional fixedness," subjects who use an object or see it used in a familiar way are strongly blocked from using that object in a novel way, showing the limitation associated with expertise. On the other hand, a more recent literature on customer lead userness demonstrated that expert subjects can provide more innovative solutions than manufacturers (e.g. Jeppensen and Frenderiksen, 2006; Stock et al. 2014). Hence, manager have to *sense* opportunities on who are we going to address the problem (common user vs lead user), and make a choice on the target audience on **Lead user vs Common users**.

2. Seizing opportunities: "formulate the problem, or not"

Once sensed opportunities of problem identification and definition are established, companies have to focus on problem formulation. According to Teece's (2007) view of DCs, once external transfer opportunities have been 'sensed', they need to be 'seized' to realize their full potential and translate them into positive outcomes. *seizing* refers to the organizational

strategy and infrastructure for making appropriate decisions and absorbing and integrating resources to create and capture value from addressing opportunities (Katkalo et al., 2010)
In other words, this is achieved by choosing organizational mechanisms that efficiently govern search (Nickerson and Zenger, 2004). As a result, in the perspective of problem-solving process, most of studies on problem formulation issues focus on the crucial distinction between well-structured and ill-structured problems or not structured at all. However, as noted by Von Hippel and Von Krogh (2013), often, in the case of managerial problems, solvers do not expect to find the optimal solution, given problem complexity and the level of resources available to conduct the work. Under these conditions, "satisficing search" algorithms are used to identify any satisfactory solution, where no distinction is being made among alternative satisfactory solutions (Simon 1978, Greiner 1996; Greiner et al. 2006). At the same time, Von Hippel and Von Krogh (2013) explain that, problem solving then consists of making a link between a specific point on a need landscape and a specific point on a solution landscape and they term these linked points a "need-solution pair." In other words, and in a context of crowdsourcing, firms can decide to introduce the problem to the crowd without formulation, but rather on attempting a defined solution landscape through participants' interaction. Hence, the company seems to face up to two different choices, one is formulate the problem; the other is to adopt a NSP approach. This decision-making process is the seizing part of the dynamic problem-solving process.

Yet, Even if NSP implies to solve problem without problem formulation, Von Hippel and Von Krogh (2013) introduce the idea of iteratively reformulate problems to discover need-solution pairs. They posit that r*ather than "going broad," it is possible to start problem solving with a precisely formulated problem, and then iteratively adjust it as problem solving proceeds in order to increase the chance of discovering viable need-solution pairs.* Thus, in integrating idea evolutionary view, we explain how the two approaches work together, in a context of ideation platform. We explain this process in the following point.

3. Capabilities reconfiguration: idea elaboration process

The final step in the problem solving process is the problem-finding, or the search for solution. The problem-finding and problem-solving approach thus far has generated several

new hypotheses, suggesting a new set of questions for management research (Nickerson et al., 2007) that can limit and narrow problem formulation (Nickerson et al., 2012).

Yet, in this final step, the problem is formulated or not formulated and is now introduced to the crowd. In adopting a dynamic view of the problem-solving process, we associate the reconfiguration of capabilities with the idea elaboration phase (Csikszentmihalyi, 1997; Staw, 1990). In other words, if the problem has been formulated, interactions among participants are going to create a solution landscape, transforming PF approach to NSP approach. Conversely, if the problem has been posted in a more common form on the crowd, then individuals are going to reformulate it during their interactions. In other words, the two approaches are completing each other as the output of one will nurture the input of the others due to the iterative process that is happen within a crowdsourcing context. This iteration process enable to avoid constrains of problem formulations.

However, it has been admitted that some solutions may be better than others, which has implications for how much value is created and which firms can capture value from search of solutions (e.g. Nickerson et al., 2012). Yet, if we come back to our example on the ideation platform, participants are going to reflect on potential solutions through idea generation process. As we have already explained, idea variations between participants are going to make the idea progress, until the optimal one. On the other side, The reconfiguration aspect of DCs refer to indicates that the likelihood of achieving financial success depends on events and responses to them. A key to sustained profitable growth is the ability to recombine and to reconfigure assets (Teece, 2007). Thus, idea elaboration phase and variations among participants allow reconfiguring assets produces by customers, and optimization of the idea generation process. Indeed, the ideation platform allows focusing on the idea which obtains the most of votes, comments or likes, but only after several iterations between PF and NSP among participants. Thus, the end of the process will determine the most valuable idea (solution) to answer the process.

Conclusion

In this paper, we introduce the idea to couple dynamic capabilities theory with idea evolutionary theory to explain the optimization of problem-solving process in a context of crowdsourcing (idea generation platform). The next step is to empirically test our model. In that sense, we are working with a crowdsourcing platform company, which turns complex

challenge into creative competition to the crowd. We access data on the two processes we developed: open or closed challenges. We have to then analyze data to understand the differences between formulate or not the problem, and the impacts on solutions/ideas innovativeness.

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Article 4

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What Influences the Creative Performance of Innovative Customers? An Application of Amabile's Componential Model

Clémence Cheruy, Nassim Belbaly and Calin Gurau

Introduction

High levels of competition and the rapid evolution of market trend require companies to accelerate and improve the performance of their new product development (NPD) process. By applying the open innovation model (Chesbrough, 2003) to individual customers (Piller, 2010), researchers identified product users as an important source of expertise and creative ideas.

This new area of study spanned a complex web of parallel concepts and models, among which, the segment of lead users probably got most of attention. The term was coined by Van Hippel (1986), to describe a specific type of consumer defined by two characteristics: (1) they are at the edge, or ahead, of the actual market trends, and (2) they enjoy significant benefits in finding solutions to their needs. The creative output of these lead users can be therefore harnessed by innovative companies to launch NPD projects or improve the existing products/services.

Although researchers in innovation acknowledged the existence of lead users, several voices indicated that valuable NPD ideas can be also sourced from other types of consumers – emergent (Hoffmann et al., 2010) or creative (Berthon et al., 2007) consumers. The introduction of these concepts, somehow larger than the lead user category, was determined by the perceived limitations of the lead user theory and method. In this study we investigate the performance of creative ideas generated by the uses of a specific consumer product – electronic tablets – going back to the roots of the creative process, explained through the componential theory of creativity (Amabile, 1996). Considering the main individual

determinants of creative performance – creative skills, domain-related expertise, and task motivation, we apply this model to a group of electronic table users to evaluate the effect of these components on the performance of the generated ideas. We connect this empirical framework with the concept of creative consumers (Berthon et al., 2007), as the research indicated that these tablet users were neither experience new market needs, nor expect significant extrinsic benefits from their idea generation.

Theoretical background

The lead user concept, initially defined by Von Hippel (1986), was later developed into a full theory of innovative ideas' generation by a series of authors (Franke et al., 2006; Lilien et al., 2002; Lüthje and Herstatt, 2004). However, despite its popularity, the lead-user model has also attracted a series of criticisms (Breach, 2008; Intrachooto, 2004):

- the lead user method is ineffective in some market areas, where these users cannot directly benefit from the proposed innovations;
- the lead user method requires high resource costs;
- the effectiveness of the methods proposed to identified lead users are still to be verified, as the specificity of lead users makes it a very rare species of customers.

Finally, we consider that the definition of lead uses as "ahead of trend" customers can only be made a posteriori, after the trend has evolved, as there are different possible future alternative trends in a market, and various customers may follow various alternatives – so who can say with sufficient certitude that a lead user is really "ahead of trend", or "outside of trend"?

The concepts of emergent customer (Hoffman et al., 2010) and creative customer (Berthon et al., 2007) have been consequently proposed in the literature to enlarge the scope and the profile of customers' innovativeness. The emergent customer is defined as users that possess "an 'emergent nature', defined as the unique capability to imagine or envision how concepts might be further developed so that they will be successful in the mainstream marketplace"(Hoffmann et al., 2009, p. 855). The main and probably the only difference between emergent customers and lead users consists in their level of expertise – while lead users are usually experts in a narrow domain field, emergent customers have only general knowledge about the market (Vernette and Hamdi-Kindar, 2014). On the other hand, the creative customers (Berthon et al., 2007) are defined as a completely different category in

comparison with lead users, being people who work with all kinds of products/services, and not only novel or emerging concepts, do not necessarily face needs that will become general, do not directly benefit from their creative input, and often innovate independently having no collaboration relationship with the producing firm.

Despite their differences, these three theories developed around the concept of user innovativeness, focus either on the personality characteristics and traits of these customers or on the process required to develop and enhance their participation to the NPD process. However, they seem to ignore the importance of understanding the creative cognitive process which characterizes the innovative customers, and its impact on the performance of their creative output. We address this knowledge gap by applying the componential model of creativity developed by Amabile (1996) to the situation of innovative customers. In line with this model, we hypothesize the direct impact of the three main components of creative cognitive processing: creative skills, domain-specific knowledge and task motivation on the performance of the creative ideas developed by customers. In addition, we explore the potential moderating effect of domain-specific knowledge and task motivation on the relationship between creative skills and creative performance, as these two components may enhance the novelty and the usefulness of the generated ideas for a specific type of product.

Research methodology

The model was tested with young managers contacted through the executive education program at a top ten business school in France. These young managers have between 23 to 27 years old, and are coming from different French regions and industries, having various types of responsibilities in their firms.

Data collection

The study was based on an ideation contest related to an emerging technology, i.e., an "electronic tablet". The respondents – all actual users of this product, were asked to contribute to the next generation of "tablets" by proposing new ideas and improvements for products already available on the market. We contacted a total of 550 potential respondents via e-mail sending them a request to participate in our online ideation contest and online survey. We received positive responses from 463 users - 52% female and 48% male, who participated in our online ideation challenge: *Contribute to the next generation of tablet.*

Measurement

Wherever possible, measures were adapted from prior research. Measures for performance were operationalized as idea originality and feasibility, using five items adapted from Leimeister et al. (2009) and Poetz and Schreier (2012). Measures for customers' expertise were adapted from Franke et al. (2006), using four items. Customer motivation was measured using three items from Luthje (2000, 2004). We used three items to measure originality, adapted from Farmer et al. (2008) and Tierney et al. (1999). Intuition was measured with three items adapted from Kaufman (2009) and, openness using three items from Zhou and Zhou (2001).

Analysis

A first step in establishing factorial validity is to determine which constructs are formative and which are reflective (Diamantopoulos and Winklhofer, 2001). We note that all measures adapted for this study have been previously modeled and measured as reflective, first-order constructs. After data collection, the measures were subjected to a purification process to assess their reliability and validity (Anderson and Gerbing, 1984; Fornell and Larcker, 1981). The validity of the measures was examined in the two-step approach recommended by Anderson and Gerbing (1988). First, an exploratory factor analysis was conducted to assess the underlying factor structure of the items that measured each construct. The exploratory factor analysis was conducted including 21 measured items of six variables, using a principal component with a Promax rotation and an eigenvalue of 1 as the cutoff point. The Kaiser–Meyer–Olkin measure of sampling adequacy was 0.905, and the Bartlett test of sphericity was significant at p <.001 (χ^2 (210) = 8153.30), indicating the suitability of this data for factor analytic procedures. A single factor was extracted for each multiple-item scale in this analysis.

The next step in the pre-analysis stage was to establish factorial validity and the reliability of the measures used. Since most constructs and many relationships hypothesized in the model are derived from prior literature, we chose to use confirmatory factor analysis (CFA) to validate the measurement model. Satisfied that the model was a good fit to the data, we could then calculate correlations, reliabilities, and AVEs to further aid in establishing factorial validity.

All data validation and model testing was completed using SPSS and AMOS part the IBM SPSS statistics package 20. We used the partial least squares (PLS) approach (Chin, 2003) and the bootstrapping resampling method (Chin, 1998) to estimate both the main and the interaction effects in our proposed model. This procedure entailed generating 1000 subsamples of cases randomly selected, with replacement, from the original data.

Path coefficients were generated for each randomly selected subsample. As suggested by Chin, Marcolin, and Newsted (2003), we employed a hierarchical approach to test our hypotheses.

Results

The results of our empirical analysis validate the model proposed by Amabile (1996), indicating that customer's creativity, expertise and motivation have a positive impact on the performance of their creativity output. On the other hand, the investigation of the moderation effects of customer knowledge and motivation on the relationship between individual creativity and output performance shows some interesting results. Customer motivation has no moderation effect on the link between customer's creativity and his/per creative performance, but customer's expertise has a negative moderating effect. In our opinion, this intriguing result, reinforces the model of creative customer proposed by Berthon et al. (2007), and converges with the view that expertise – defined as detailed and deep knowledge about a specific field, and in our case, about the electronic table, can stifle creativity, leading to less innovative ideas (Weisberg, 1999). Creativity researchers found that creative breakthroughs tend to happen early in a professional career, when the level of expertise is moderate (Simonton, 2003), as high levels of expertise causes people to fixate or develop tunnel vision when approaching problems (Sasser and Koslow, 2012). Our results represent a finer interpretation of this problem, indicating both the importance and the limits of expertise in individual creative cognitive processes: on the one hand, domain-related expertise represents one (together with creativity and motivation) of the three main pillars of creative output – impacting positively the creative performance of customers; on the other hand, customer's expertise moderates negatively the relationship between individual creative skills and creative performance, as deep knowledge can reduce the freedom and range of creative cognitive processing.

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Article 5

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Effects of IT tools and motivational factors on leadership style and creativity of consumers

Nassim BELBALY*, Clémence CHERUY*, Frank ROBERT*

* Montpellier Business School

ABSTRACT

It is now admitted that companies often outsource problem-solving process in order to gather innovative ideas from users. Using a sample of more than 400 French managers participating to an executive education program, we investigated e-leadership behavior of customers in a context of online ideation challenge as source of creativity. We developed and tested a model arguing that five dimensions of IT tools (tool support, task involvement, enjoyment, intrinsic and extrinsic motivation) positively influence transformational leadership of customers, which directly impacts virtual communities' creativity and thus outputs' innovativeness. Results of the study provide support for this model showing that transformational leaders emerges through ideation context, and directly impact creativity of individuals during the challenge.

Keywords:

User Creativity, Ideation, e-leadership

1. Introduction

Leadership is an important topic in management literature, which attracts numerous researchers' interest. In IS field, Advance Information Technology (AIT) pushes academics to study leadership in a new environment where individuals work virtually, at distance, and using very fast evolving tools and knowledge. In such environment, not only leaders' knowledge structures are changing as a result of greater accessibility of information, but the nature of leadership is also changing (Shamir, 1997). Consequently, literature mainly focused on e-leadership, which is defined as a social influence process mediated by AIT to produce a change in attitudes, feelings, thinking, behavior, and/or performance with individuals, groups, and/or organizations (Avolio, Kahai, & Dodge, 2001). However, even if e-leadership theories have been largely developed and studied (e.g. Avolio et al. 2001; Golden, Vega, & Dino, 2008), main studies focus on an internal context, and more precisely on employees' leadership and creativity. Yet, it now admits that more and more companies are opening their borders as a salient way to gain and maintain competitive advantages. This openness is often characterized by the use of crowdsourcing techniques in order to catch external features (Jeppesen & Lakhani 2010). One of the main challenges is to better understand customer needs in order to provide better answers to those needs. Therefore, firms have usually involved and motivated online community's creative solutions of a distributed network of individuals through the format of open challenges labeled as *ideation challenge* (Howe, 2006; Brabham, 2008).

For these reasons, we need to understand how do these virtual communities work, and more important, how to enhance creative ideas from online customers interactions.

As a result, based on e-leadership theories and motivation theories, we argue that ideation context and tools support may influence customer transformational leadership and customers' creativity during open challenge.

2. Model development

Several studies have tried to understand the link between intrinsic motivation and creativity. It has been proved that contextual moderators as task complexity and leader-member exchange (Tierney, Farmer, & Graen, 1999) stimulate the creativity of people who are intrinsically motivated by providing them challenges and constraints (Grant & Berry, 2011).

In innovation literature, we know that users innovate because they expect to obtain short-term benefits from their innovations (Von Hippel, 1982). Such benefits are not necessarily monetary, but motivation also refers to intrinsic motivation, which is recognized as an important factor of creativity (Amabile, 1997).

Research in Open Source Project suggested that engaging in intellectual pursuits and solving challenging problems is one of the main drivers of participation and motivation (Lakhani & Wolf, 2005) and cognitively engaging and creative tasks are considered as intrinsically interesting (Amabile, 1996). Yet, it has been proved that customers engaging in virtual co-creation during NPD may be interested in the virtual innovation task. They may want to come up with new ideas, solve stated problems, or evaluate proposed solutions, independent of the respective product category. Individuals who are intrinsically motivated consider their virtual contribution to NPD as a meaningful activity (Fuller et al. 2009). This notion of enjoyment has been studied by several authors (Csikszentmihalyi, 2002; Jawecki, 2008) who demonstrated the playful element of innovation and participants in virtual NPD tasks who feel supported by the provided interaction tools may perceive their task as enjoyable (Fuller, Muhlbacher, Matzler, & Jawecki, 2009). Therefore, we argue that in an ideation challenge, customers are involved in an innovation task which initiates enjoyment of customers. We thus investigate the following hypodissertation:

H1: Task involvement in online innovation challenge has a positive impact on customers' enjoyment.

H2: Consumers' intrinsic motivation to innovate has a positive impact on customers 'enjoyment

Our studies are designed in an online framework, in a context of idea generation contest. According to Adaptive Structuration Theory (AST) (DeSanctis & Poole's, 1994), human action is guided by structures, which are defined as rules and resources that serve as templates for planning and accomplishing tasks. The emergence of Advanced Information Technology (AIT) provides new structures and environment for users and workers, which modify users action (Avolio et al. 2001). For instance, the Electronic Brainstorming features and spirit is to promote participation and might be described as analogous to promoting participative leadership and can become a structure for promoting innovative ideas (Nunamaker, Briggs, Mittleman, Vogel, & Balthazard, 1997). As an Electronic Brainstorming, we assume that an

ideation platform constitute a powerful tool which enhances users participation and therefore customers enjoyment. As explained before, companies are increasingly searching for the most innovative consumers through open challenge in using online ideation platform. Thus, we explore the following hypodissertation:

H3: tool support underlies an online context that positively influences customers 'enjoyment.

A transformational leader influences group members' motivation to participate and cooperate via intellectual stimulation (IS), individualized consideration (IC), and inspirational motivation (IM) behaviors (Kahai, Sosik, & Avolio, 2003). Moreover, Balthazard, Waldman, and Warren (2009) proved that and it has been proved emergent leader as group members who exert significant influence over other members of the group although no formal authority. Concerning the ideation context, the authors showed that initiation of ideas will predict the perceived emergence of transformational leadership in virtual teams and frequency of participation will predict the perceived emergence of transformational leadership in virtual teams. Thus, we argue that enjoyment perceived in ideation challenge influences emergence of transformational leader, and investigate the following hypodissertation:

H4: during an ideation challenge, perceived enjoyment has a positive influence on transformational leader emergence.

Complementary, other authors showed that different factors of a leader can influence their followers' creativity. For example, use a collaborative group technology such as electronic meeting system has a positive impact on group creativity (Kahai et al. 2003; Nunamaker et al., 1997). For example, Sosik, Avolio, and Kahai (1997) showed that transformational leadership behaviors can enhance group potency beliefs, which promote more creative group outcomes in turn. Moreover, Avolio et al. (2014) explained that "as relationships develop over time and higher levels of trust emerge, e-leaders may be able to shift to more participatory and transformational behaviors, which may allow for a greater exchange of ideas, enhanced information flow, and generation of more creative solutions". And, it has also been proved that Transformational leadership may be especially potent in online contexts, which create de-individuating effects with followers thereby making the group's identity more salient than individual identities and critical analysis and debate more comfortable (Eisenbeiss,

Blechschmidt, Backhaus, & Freund, 2012). Therefore, we posit the following hypodissertation:

H5: transformational leadership interaction during ideation platform is a predictor a creative outcomes.

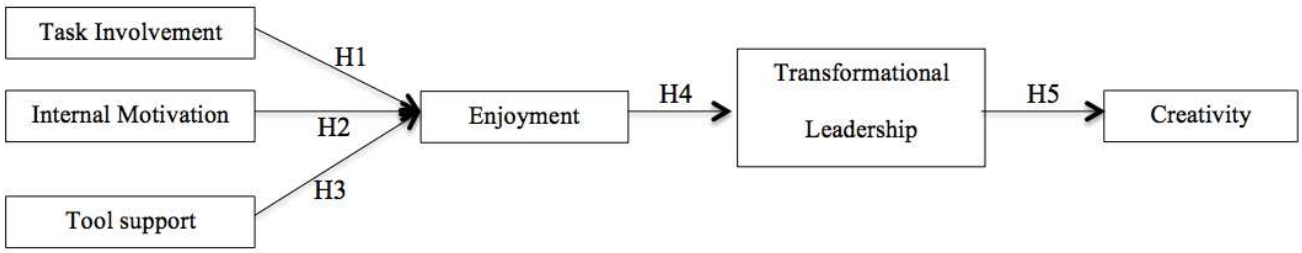

Figure 1: Influence of IT tools on leadership style and creative outcomes

3. Method

3.1. Sampling Frame

The sampling frame was composed of 650 French managers participating to an executive education program. We have sent an email asking them to participate to our research. Respondents were managers with responsibilities in different domains all over France. A wide variety of job titles were observed from HR, marketing, financial, accounting etc…. We have received 401 questionnaires (61% of 650 mailed).

3.2. Measurement

The reliability coefficients ranged from 0.875 to 0.962 and thus were acceptable (Nunnally, 1978) (see also Table 1).

Transformational leadership was measured using three items (Adapted from Balthazard et al. 2009) scale at α=0,921

Enjoyment was measured using four items (adapted from Fuller et al. 2009) scale at α= 0,967

Tool support was measured using four items (adapted from Fuller et al. 2009) scale at α= 0,962.

Task involvement was measured using three items (Fuller et al. 2009) scale at α= 0,934.
Intrinsic motivations was measured using four items (Adapted from Gray & Meister, 2004) scale at α=0,943
Creativity was measured using five items (Adapted from Tierney et al., 1999; Zhou & Georges, 2001) scale at α=0,875.

4. Measurement Model Validation

After data collection, the measures were subjected to a purification process to assess their reliability and validity (Anderson & Gerbing, 1984; Fornell & Larcker, 1981). The validity of the measures was examined in the two-step approach recommended by Anderson and Gerbing (1988). First, an exploratory factor analysis was conducted to assess the underlying factor structure of the items that measured each construct. The exploratory factor analysis was conducted including 25 measured items of six variables, using a principal component with a Promax rotation and an eigenvalue of 1 as the cutoff point. The Kaiser–Meyer–Olkin measure of sampling adequacy was .919, and the Bartlett test of sphericity was significant at $p < .001$ (χ^2 (300) = 8468.381), indicating the suitability of this data for factor analytic procedures. A single factor was extracted for each multiple-item scale in this analysis. The items, and their factor loadings after exploratory factor analysis, eigenvalue, and percentage of variance explained, appear in Table 1.

Table 1: Discriminant Validity of Construct Measures

		Factor Rotation					
Constructs	**Items**	**F1**	**F2**	**F3**	**F4**	**F5**	**F6**
Tool Support (F1)	Q4_1	,010	,061	**,879**	,017	,039	-,008
	Q4_2	-,033	,051	**,934**	,000	,002	,019
	Q4_3	,026	,008	**,905**	,020	,009	,016
	Q4_4	-,023	,090	**,885**	-,017	,018	,012
Task Involvment (F2)	Q5_1	,034	-,056	,077	,010	**,907**	,006
	Q5_2	-,026	-,042	,067	-,011	**,964**	-,031
	Q5_3	,004	,057	-,076	-,007	**,935**	,008
Enjoyement (F3)	Q6_1	,014	**,922**	,007	-,012	,034	-,007
	Q6_2	,003	**,909**	,050	,030	-,014	,002
	Q6_3	,031	**,920**	,053	-,009	-,031	-,016
	Q6_4	,010	**,927**	,041	-,010	-,014	,005
	Q6_5	,206	**,684**	,124	-,020	-,022	-,015
Creativity (F4)	Q34	,006	,138	-,192	**,764**	,122	,017
	Q35	-,137	,222	-,130	**,759**	,034	,077
	Q37	,026	-,066	,024	**,839**	,018	,026
	Q38	,071	-,168	,128	**,847**	-,085	-,031
	Q39	,024	-,085	,142	**,866**	-,071	-,075
Transformational Leadership (F5)	Q63_1	,063	-,058	,021	-,002	,000	**,908**
	Q63_3	,024	-,011	-,002	-,010	-,006	**,950**
	Q63_4	-,060	,041	,021	,013	-,013	**,918**
	Q7_1	**,910**	-,006	,004	,003	,024	,018

Motivation to post idea (F6)	Q7_2	**,934**	-,023	,028	-,025	,040	-,001
	Q7_3	**,923**	,011	-,018	-,001	-,009	,032
	Q7_4	**,851**	,086	-,080	,044	,029	,006
	Q7_5	**,789**	,074	,036	-,008	-,071	-,033
Eigenvalue		**11,47**	**3,36**	**2,04**	**1,49**	**1,41**	**1**
Percentage of variance explained		**45,9**	**13,44**	**8,19**	**5,96**	**5,63**	**4,01**

After performing the exploratory factor analysis, which is a useful technique for scale construction, we also conducted a confirmatory analysis to assess the resulting scales by measuring internal consistency, reliability, and convergent validity. First all items loaded significantly on their respective constructs (with the lowest *t*-value being 9,27), providing support for convergent validity.

Composite reliabilities estimates exceeded the standard suggested by Bagozzi, Yi, and Phillips (1991) greater than .70. Values of average variance extracted (AVE) provided satisfactory results over .50. Standardized item loadings for all constructs were greater than .50 and significant ($p<.05$), evidencing good convergent validity (Bagozzi et al., 1991). An inspection of alpha coefficients revealed that all values were equal or greater than .875, which indicates good reliability.

Table 2 shows the correlation among all 6 variables. The relatively low to moderate correlations provide further evidence of discriminant validity. Further, as suggested by Fornell and Larcker (1981), the squared root of AVE for each construct was greater than the latent factor correlations between pairs of constructs, suggesting discriminant validity. The conclusion is that the measures are unidimensional and have adequate reliability and discriminant validity.

Table 2. Correlations

Variables	F1	F2	F3	F4	F5	F6
Tool Support (F1)	0,912					
Task Involvement (F2)	,677**	0,931				
Enjoyment (F3)	,559**	,664**	0,929			
Creativity (F4)	,316**	,203**	,110*	0,894		
Transformational Leadership (F5)	,411**	,406**	,393**	,240**	0,783	
Motivation to post idea (F6)	,496**	,442**	,346**	,366**	,243**	0,886

** p <0.01 two tailed

* p < 0.05 two tailed

Diagonals show the square root of AVE's

5. Model Measurement

We have used Amos to make a structural equation modelling analysis to measure the model and evaluate our hypotheses. The resulting measurement model was found to fit the data reasonably well: $\chi^2(260) = 616{,}81$, comparative fit index (*CFI*) = .966, incremental fit index (*IFI*) = .966, Tucker–Lewis Index (*TLI*) = .960, χ^2/ (d.f.) = 2.372, and root mean square error of approximation (*RMSEA*) = .06.

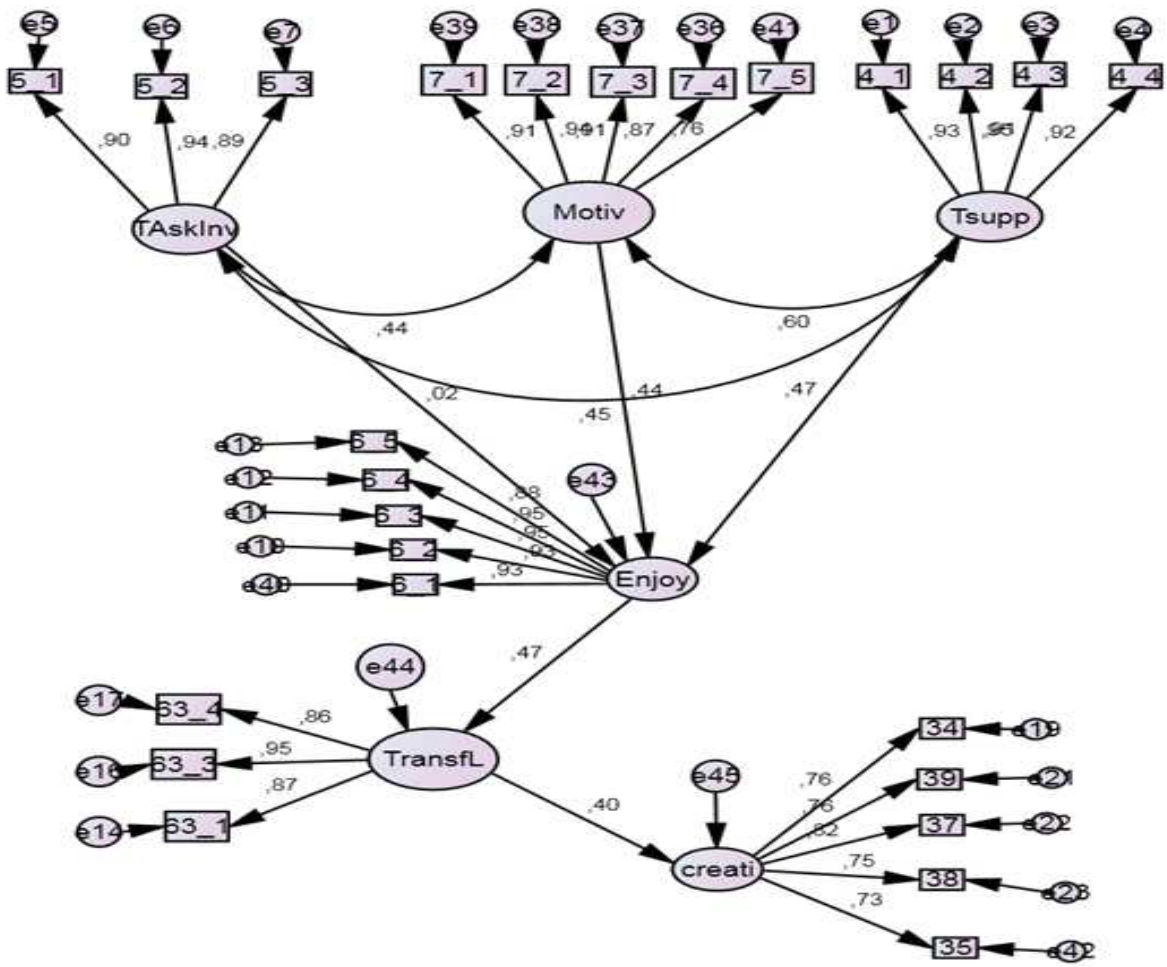

Figure 2: Structural equation modelling of the hypothesized model

The results of the structural equation modelling are presented in Figure 2. These results generally support the conceptual idea of this study that Internal Motivation, Tool support influence positively Enjoyment which impact Transformational Leadership and Creativity.

As noted, except for H1 which is not significant, otherwise H2, H3, H4 and H5 are Significant at $p<0.01$. H2 and H3 are significantly correlated with Enjoyment respectively with $r = 0,44$ at $p < .01$ and $r = 0,47$ at $p < .01$. Concerning H4 is also supported as there is a significant relationship between Enjoyment and Transformational leadership with $r = 0,47$ at $p < .01$. And finally, H5 is supported as the empirical analysis demonstrate that the Transformational leadership is significantly correlated with creativity with $r= 0,40$ at $p < .01$.

6. Conclusion

Our study was designed to investigate the potential leadership of customers and its implication on creativity in a virtual context. Although leadership literature and customers behaviors are two research fields fully investigated, the combination of these two factors still remains little explored.

6.1. Theoretical contribution

A recent study in this line has explored the heterogeneous roles of ideation contest participants in order to a better theoretical understanding of distinctive user types in innovation-contest communities (Fuller, Hutter, Hautz, & Matzler, 2014). Our study deeply investigates customers' behavior during ideation contests and more specifically, the influence of transformational leadership of customers on virtual communities' creativity. We found that a context of ideation positively impacts the emergence of transformational leaders in virtual consumers' community. In other words, we provide some understanding on how virtual structure can impact user roles during ideation context. In their work, Fuller et al. (2009) described customers experience during virtual co-creation tasks. They showed that customer's empowerment depends on the design of tool support, interaction of users and related enjoyment.

In our study, we strengthen these findings by showing that customer experience also impacts customer's roles and creativity emergence. First, bycombining e-leadership theories in a co-creation context, we showed that transformational leaders in online customers' community emerge with the perceived enjoyment of ideation tasks, and attractiveness of tools support. Second, we showed that these customers' transformational leadership trait leads to enhance customers' creative behavior during ideation contests.

6.2. Managerial Implication

Having the right technology-based system can enhance customer experience and help companies improving both their innovation and customer relationship management capabilities. However, it remains very difficult for companies to catch creative ideas from customers. Our research contributes through several points to improve the New Product Development (NPD) process with customers. In our study, we showed that an online ideation

platform offers a particular context adapted to enhance user creativity. By using this kind of tools, companies could develop their capacity to identify innovative customers. More specifically, it useful for firms to recognize that the kind of challenge, the virtual tools, and the way to accomplish tasks represent a powerful tool to enhance customers' creativity and improve external NPD process.

A better understanding of customers experience and roles provides another advantage to co-creation effectiveness.

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Résumé de la thèse en français

Introduction

Qui aurait pu imaginer, quinze ans auparavant, qu'une multinationale puisse confier à un citoyen lambda la conception d'un produit qui attirerait l'attention du monde entier ? En 2008, ce rêve est devenu réalité pour Carlos Arturo Torres, un jeune étudiant Colombien, sélectionné pour présenter "la voiture pour la mégalopole du futur" à la *Shanghai International Automobile Industry Exhibition*. Carlos Torres a remporté un concours de design lancé par Peugeot en 2008, où il était demandé aux participants de concevoir la voiture de demain. L'idée du jeune colombien a été sélectionnée parmi plus de 2500 concepts proposés, lui faisant remporter la somme de 10000 euros et la possibilité de participer à l'*Auto Shanghai 2008*, parmi d'autres récompenses. Peugeot s'est également engagé à produire le concept de Carlos Torres en série limitée pour les collectionneurs.

Grâce à ce type d'initiative, une marque peut tenir compte des aspirations et des exigences des consommateurs tout en permettant à ces derniers de prendre part à la conception même du produit. De nombreuses marques utilisant aujourd'hui des initiatives basées sur le web afin de faire participer les internautes à la création des logos, la conception des produits ou encore l'amélioration des services, le phénomène est devenu monnaie courante pour les marques et l'industrie, mais également d'une manière plus étendue et diversifiée. Ce type d'initiative est apparu il y a de nombreuses années. En effet, une autre manière d'inclure des individus externes à l'entreprise existait déjà au travers de ce que l'on nomme le sponsoring participatif, des volontaires réalisant des donations pour une cause spécifique. La rénovation des monuments historiques français en est un bon exemple. La remise en état de plusieurs monuments français, tels que le Panthéon pour n'en citer qu'un, a été totalement financée par les dons des particuliers.

Le besoin qu'ont les organisations de compter sur des sources externes pour atteindre un but spécifique, qui pourrait être un objectif financier ou simplement la collecte d'idées potentielles, est compréhensible. Ce phénomène pourrait s'expliquer par deux points principaux. Premièrement, l'environnement actuel, incluant la mondialisation et le développement des

technologies de l'information, pousse les compagnies à se reposer davantage sur l'innovation pour la génération de performance économique (OCDE 2008). L'innovation devient l'une des sources les plus importantes d'expansion et de génération de valeur ajoutée des entreprises. Pour de nombreuses organisations, le besoin d'innovation est alors intégré au cœur même des produits, services et opérations (Yoo et al. 2012).

Dans un deuxième temps, tandis que l'innovation devient l'une des préoccupations principales des entreprises, les avancées technologiques et l'expansion d'Internet poussent celles-ci à utiliser et développer de nouvelles techniques et à trouver de nouvelles sources afin d'obtenir des résultats novateurs. L'adoption grandissante des innovations résultant des technologies numériques change radicalement la nature des produits et des services, poussant les organisations à redéfinir totalement les manières de créer cette innovation. Les exemples mentionnés précédemment illustrent dans un premier temps la nécessité d'ouvrir les frontières de l'entreprise et de voir au-delà du cadre traditionnel des affaires, et dans un deuxième temps celle d'utiliser l'environnement numérique pour aller chercher ces nouvelles sources d'innovation. Par conséquent, la compréhension de cette innovation est l'un des enjeux les plus importants pour le gain d'avantages compétitifs durables, poussant les entreprises à adopter des approches ouvertes en s'ouvrant vers l'extérieur, partageant les connaissances et les pratiques internes, et intégrant des acteurs externes dans les processus de prise de décision (Chesbrough 2006). Le paradigme de l'innovation ouverte représente alors pour les compagnies une opportunité saillante de développer de nouveaux produits et services commercialement attractifs, et soulève également de nouvelles questions autant d'un point de vue pratique que théorique. Ce nouveau paradigme se place à la base de notre travail de recherche.

Objectifs de Recherche

Les chercheurs se sont communément mis d'accord sur le fait que l'utilisation de l'environnement digital « démocratise » le processus d'innovation, redéfinissant le contrôle des activités d'innovation à travers de multiples systèmes (Chesbrough et al. 2006). Par conséquent, la zone géographique d'innovation s'étend au-delà de l'enceinte des entreprises, ce qui modifie la manière dont la créativité est exploitée, ainsi que le développement de nouveaux produits et des idées novatrices. Par conséquent, les entreprises tirent parti de nouvelles formes d'organisation (Yoo et

al.2012).

Premièrement, l'évolution du comportement des entreprises découle de la réalisation croissante que le meilleur moyen de conserver les clients et de répondre à leur besoins en constante évolution est de les inclure dans le développement des nouveaux produits de l'entreprise (von Hippel 2005). Aujourd'hui, les consommateurs sont également davantage enclins à prendre part aux expériences de développement de nouveaux produits, comme cela est montré par les résultats d'études internationales, qui supputent que 6.1 % de la population du Royaume-Uni, 5.2 % de celle des États-Unis et 3.7 % de celle du Japon ont été impliqués dans des activités d'innovation servant leurs propres besoins pour la création ou la modification de produits de consommation (von Hippel et al. 2012 ; Ogawa & Pongtanalert 2013). Alors que ce mouvement et ces pratiques de co-création sont en continuelle expansion, cela suscite l'intérêt des universitaires, qui cherchent à comprendre et expliquer le rôle des utilisateurs extérieurs dans les activités d'innovation des entreprises (e.g. Bogers et al. 2010).

Deuxièmement, les deux exemples précédemment évoqués révèlent clairement que les entreprises utilisent également l'émergence de l'environnement numérique comme moyen d'interaction avec des sources externes, et cela dans le monde entier. En effet, ce mouvement de co-création est accentué par l'expansion des nouvelles technologies, qui facilite les interactions avec les autres utilisateurs et consommateurs. Une approche basée sur l'utilisation des technologies de l'information qui reçoit une attention substantielle est le « *crowdsourcing* », un néologisme créé pour définir l'action d'externaliser une tâche réalisée par un employé à un large groupe de personnes extérieures à l'entreprise sous la forme d'un appel ouvert (Howe 2006). La compréhension des facteurs clé qui régissent la génération des idées qu'une organisation souhaite implémenter est alors nécessaire pour profiter de la totalité du potentiel de ces communautés de *crowdsourcing* (Bayus 2013).

Il est donc nécessaire pour les entreprises d'implémenter de nouvelles formes d'activité d'innovation inscrites dans le paradigme de l'innovation ouverte. En ouvrant leurs frontières, les entreprises pourraient augmenter leurs chances d'exploiter la créativité et améliorer le caractère innovant du développement des nouveaux produits (NPD). Ce mouvement de co-création est représenté par 1) l'inclusion des utilisateurs externes dans le processus de développement des

nouveaux produits et 2) l'utilisation des techniques de *crowdsourcing* pour interagir avec des partenaires externes.

Par conséquent, l'innovation participative dans un environnement numérique grâce aux techniques de *crowdsourcing* constituent nos deux principaux objectifs de recherche, afin d'augmenter notre compréhension des mécanismes et des fonctionnements permettant ce mouvement de co-création.

Problématique Générale

Dans le but de produire des produits novateurs, il est nécessaire pour les entreprises de suivre une stratégie d'innovation en plusieurs étapes (Tidd et al. 2005), de la collecte des idées à l'implémentation du produit :

1. Recherche des opportunités : comment et quand les entreprises vont-elles trouver de nouvelles idées ?
2. Sélection : quel projet les entreprises vont-elles retenir et pourquoi ?
3. Implémentation : comment vont faire les entreprises pour que cela fonctionne ?
4. Capture : de quelle manière les entreprises peuvent-elles bénéficier de l'implémentation d'un nouveau produit ?

Comme évoqué précédemment, le processus d'innovation passe à travers un processus non-linéaire, par lequel les entreprises pourraient diversifier et partager les idées, les connaissances et les ressources afin de générer de la valeur ajoutée. En d'autres termes, la quantité de potentiel d'innovation que l'on peut verser dans l'entonnoir de l'innovation augmente car plus d'équipes sont activement impliquées, comme le montre la figure 1.

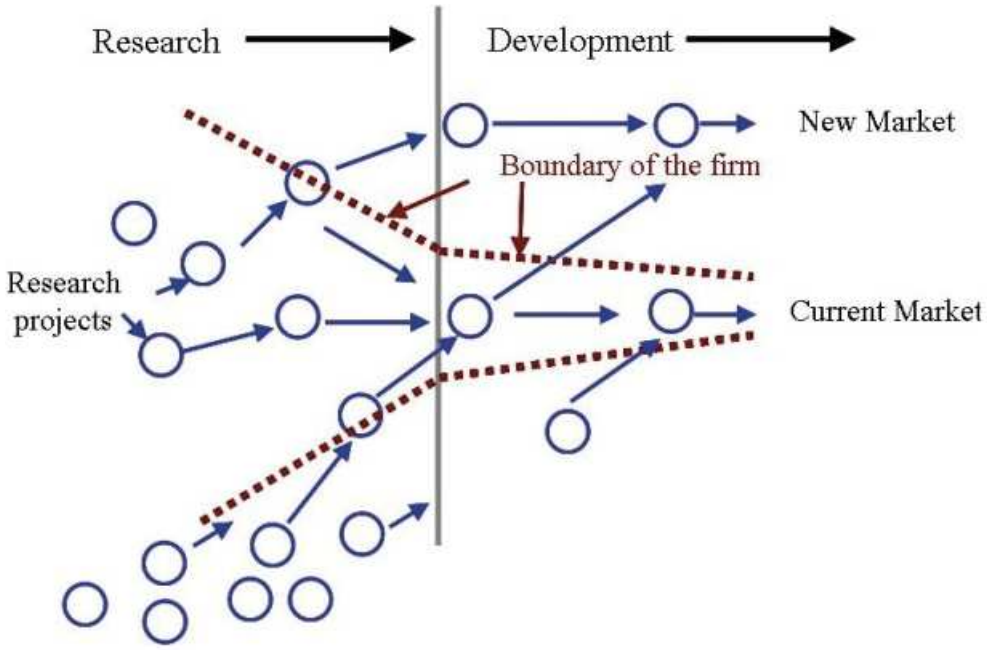

Figure 1 : modèle de l'innovation ouverte (Chesbrough 2003)

Comme proposé par Chesbrough (2003), de nouvelles opportunités ou idées proviennent de sources externes. Dans le but d'étudier le mécanisme global permettant aux entreprises de développer des innovations à partir de sources externes, notre travail de recherche se focalisera alors sur le stade précoce de l'entonnoir de l'innovation, à savoir la recherche de nouvelles opportunités.

La littérature liée à l'innovation participative suggère qu'intégrer des clients ou des utilisateurs aux stades précoces du processus d'innovation pourrait potentiellement augmenter la probabilité d'exploiter la créativité (Bogers et al. 2010). Dans un premier temps, les idées émergeant des utilisateurs ont une forte probabilité de refléter leurs besoins et leurs désirs (Prügl & Schreier 2006), ce qui augmente les chances de développer des produits attractifs.

Dans un deuxième temps, en exprimant explicitement leurs besoins, les utilisateurs fournissent ce que l'on appelle « *solution information* », d'importantes suggestions basées sur les retours des clients, décrivant de quelle manière les idées peuvent devenir des produits commercialisables (von Hippel 1994).

Une meilleure compréhension de la nature d'innovateurs des utilisateurs pourrait ainsi augmenter les chances de comprendre pourquoi ceux-ci pourraient être prêts à s'engager dans le processus d'innovation. Tandis que les entreprises ont besoin de renforcer leurs connaissances en détection de l'innovateur externe, les chercheurs ont communément reconnu qu'il semble difficile de sélectionner des profils d'innovation spécifiques dans la masse des utilisateurs disponibles sur le marché (Piezunka & Dahlander 2015). De plus, la littérature liée au management de l'innovation signale que, même si les entreprises ont la capacité de détecter l'innovateur idéal, elles rencontrent toujours des difficultés à trouver comment intégrer et travailler avec des acteurs externes à l'intérieur des compagnies et comment ré-établir le processus d'innovation et le soutien managérial (Piller & Walcher 2006 ; Block et al. 2016). Notre travail de recherche s'articule donc autour de ces questionnements et a pour but d'apporter des contributions en répondant à la problématique suivante : **Quels sont les déterminants de l'innovation participative ?** Le terme « déterminants » fera référence à trois questions de recherche spécifiques :

-RQ1 : qui sont les acteurs externes qui améliorent les idées novatrices ?

-RQ2 : quels sont les meilleurs objets pour collecter ces idées ?

-RQ3 : quelles sont les meilleures méthodes pour retenir des entrées innovantes ?

Nous approchons ces questions en travaillant sur une dissertation cumulative, et chaque papier abordera l'une des questions de recherche. Néanmoins, plutôt que de présenter un simple résumé de nos papiers, nous aimerions mettre l'accent sur le lien entre ces trois niveaux d'analyse et leur impact sur 1) l'émergence du comportement créateur et 2) l'optimisation du processus d'innovation (Figure 2). Par conséquent, chaque papier présenté dans cette dissertation contribue à l'exploration de l'un des trois niveaux. Nous avons organisé les papiers en suivant un raisonnement logique à travers trois axes pour répondre aux questions de recherche spécifiques (Figure 2).

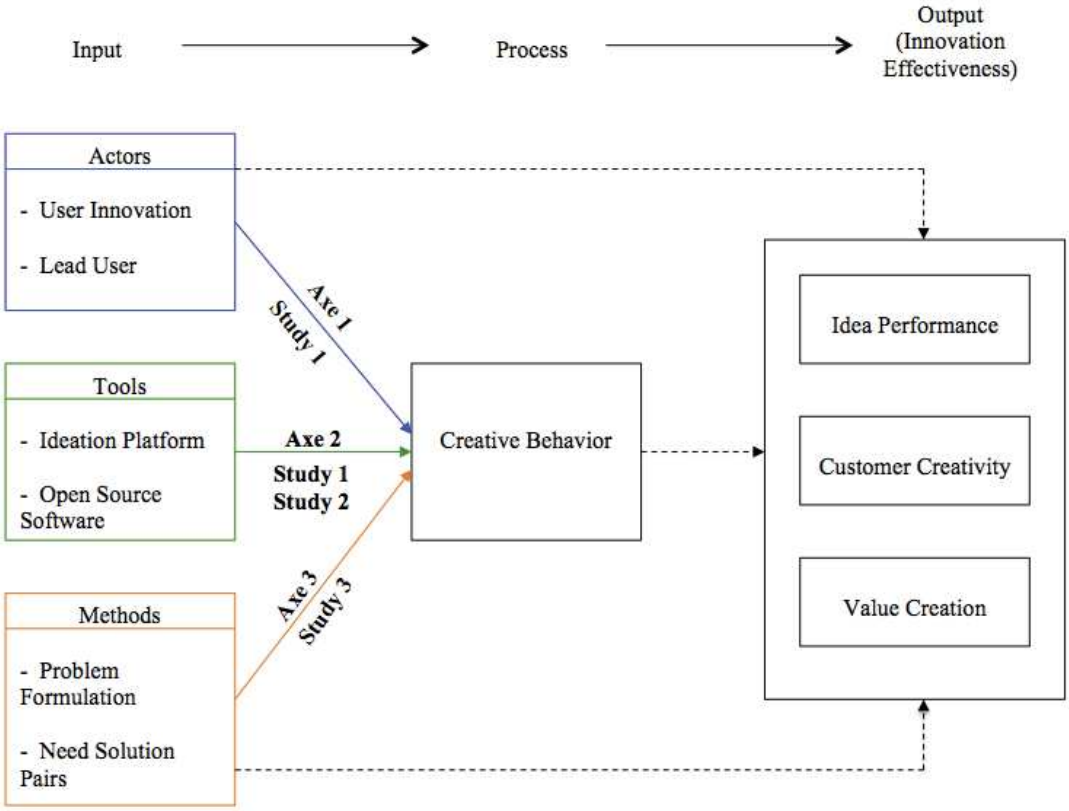

Figure 2 : Modèle conceptuel de recherche

La créativité est un sujet central dans les études d'organisation et d'innovation car elle permet aux compagnies de créer de la valeur et génère un cadre favorable au développement de nouveaux projets (Amabile et al. 1996). De plus, la créativité peut également fournir des solutions utiles pour la résolution des problèmes (Shalley et al. 2004) et un aperçu des problèmes futurs dans un environnement évoluant rapidement. Par conséquent, les chercheurs ont tenté d'expliquer les processus par lesquels les organisations pourraient exploiter la créativité (e.g. Moreau & Dahl 2005 ; Toubia 2006 ; Simonton 2011 ; Zhou & Oldham 2001). Sur le plan individuel, la créativité est définie comme une capacité « individuelle » à produire ou à

réagir d'une manière inédite et appropriée, utile, correcte, ou précieuse pour la tâche à accomplir (Amabile 1983). Cependant, dans l'environnement de travail, la créativité dépend souvent des interaction sociales et des relations (Kim et al. 2016, Sonenshein 2014 ; Amabile et al. 2005). En

prenant en compte le fait que les organisations comptent beaucoup plus sur des sources externes pour favoriser/encourager la créativité, il devient nécessaire de comprendre de quelle manière ces sources externes peuvent conduire à l'émergence du comportement créateur (Anderson et al. 2014). L'objectif de recherche de cette dissertation doctorale est l'étude des entrées (acteurs, outils et méthodes) qui mènent à la génération d'idées novatrices et utiles.

Cadre conceptuel

Chacun de ces trois axes est relatif à une question de recherche spécifique que nous avons auparavant définie en identifiant les défis de recherche à partir de littérature existante liée à chaque niveau :

- Axe 1 : les acteurs en tant que source d'innovation

- Axe 2 : les outils en tant que moyen de co-créer

- Axe 3 : les méthodes pour optimiser le processus d'innovation

L'**Axe 1** est consacré à l'étude des acteurs externes ainsi que leurs rôles et caractéristiques spécifiques en tant que sources d'innovation. Comme mentionné précédemment, notre approche est construite sur la littérature liée à l'innovation participative avec le but d'explorer plus profondément la nature et le profil de ces acteurs. Cet axe porte spécifiquement sur le lien entre les utilisateurs externes et l'émergence du comportement créateur conduisant à l'apparition d'idées novatrices potentielles. Nous cherchons donc à comprendre et étudier la manière dont les organisations peuvent détecter des utilisateurs créatifs qui seront efficaces pour la création d'idées novatrices. Pour ce faire, nous nous concentrons sur une catégorie d'utilisateurs spécifique. En effet, d'après des travaux de recherche antérieurs, une catégorie de consommateurs étiquetée « *lead users* » est reconnue comme étant particulièrement pertinente pour la génération d'idées novatrices. Un *lead user* est défini comme un utilisateur expert possédant d'une connaissance avancée du produit, et qui est en avance sur la tendance en terme de bénéfices attendus et use de l'expérience liée au produit (von Hippel 1986). Le choix de se focaliser sur les *lead users* a de nombreuses justifications, la première est que les chercheurs ont découvert que 82 % des *lead users* développaient leur propre version du produit industriel qu'ils étaient chargés d'étudier,

contre seulement 1 % des utilisateurs communs (Urban & von Hippel 1988). Deuxièmement, ils ont révélé que les produits des *lead users* étaient commercialement plus attractifs et que leurs idées suscitaient un plus grand intérêt par rapport à celles des consommateurs de masse (Urban & von Hippel 1998 ; Morisson et al. 2000). Les produits des *lead users* ont également présenté un meilleur potentiel de vente que les concepts développés de manière traditionnelle (Lilien et all. 2002). Cependant, les méthodes de détection des *lead users* souffrent encore de limitations, surtout en comptant sur des techniques de *crowdsourcing* (Spann et al. 2009). Par conséquent, nous aimerions approfondir notre compréhension du profil d'un *lead user* et cela plus précisément dans un contexte en ligne dans le but de fournir des éléments de réponse à la RQ1-qui sont les acteurs externes qui améliorent les idées innovantes ? À cet égard, l'article 1 enquête sur la nature d'un profil de *lead user* sur le net en explorant ses caractéristiques dans ce contexte spécifique.

L'Article 1 (recherche qualitative) a pour titre « Identifying lead user online : a study of a co-creation platform ». Des versions antérieures ont été présentées aux conférences *Association Information et Management* (AIM) (2014) et *European Group for Organizational Studies* (EGOS) (2014). Ce papier est, depuis Septembre 2016 en cours de relecture à la suite d'une soumission à *Research Policy*.

Cette étude contribue à l'analyse du profil en ligne d'un *lead user* en s'intéressant à la question suivante : comment détecter un *lead user* via une plate-forme d'idéation ? Pour répondre à cette question, nous nous sommes basés sur la littérature antérieure portant sur les caractéristiques des *lead users*, appliquée dans un contexte d'idéation ouverte. Nous suivons un protocole de recherche spécifique en passant tout d'abord les participants au crible afin d'identifier des *lead users* potentiels avant de réaliser des interrogatoires poussées pour valider les caractéristiques des *lead users* sur le net et confirmer leur statut de *lead user*. Nos résultats montrent des variations dans les trois caractéristiques principales par rapport à la littérature existante, nous permettant de définir une typologie en ligne du profil de *lead user*.

L'**Axe 2** étudie les outils en tant que moyens de co-créer. En utilisant des boîtes à outils sur le net, les compagnies peuvent demander aux utilisateurs de créer des concepts pour de nouveaux produits et collecter des idées novatrices via des concours de concepts sur le net (Piller & Walcher 2006 ; von Hippel & Katz 2002). Alors que l'axe 1 sous-tend le rôle des acteurs, nous

cherchons ici à mieux comprendre de quelle manière les entreprises peuvent co-créer avec des utilisateurs externes. À travers le processus de *crowdsourcing*, l'utilisateur tend à générer des idées qui ont significativement un meilleur niveau en terme de nouveauté et de bénéfice client que les méthodes traditionnelles de développement de nouveaux produits (Poetz & Szchreier 2012). Le *crowdsourcing* ayant été reconnu comme une méthode prometteuse pour rassembler les idées des utilisateurs (e.g. Afuah & Tucci 2012), nous construisons cet ensemble d'articles pour enquêter sur le rôle des outils informatiques pour influencer les innovations. Nous étudions de manière spécifique deux aspects de ces techniques de *crowdsourcing*, à travers deux outils distincts: les logiciels libres (OSS) et les plates-formes d'idéation. Nous nous concentrons premièrement sur les concours d'idées pour comprendre pourquoi de nombreuses compétitions de ce type basées sur les technologies de l'information ne parviennent pas à atteindre les exigences pour lesquelles la participation active et donc la production de résultats créatifs est établie (Leimeister et al. 2009). En d'autres termes, nous cherchons à comprendre quelles sont les conditions sur les boîtes à outil des compétitions d'idées qui mènent à l'émergence du comportement créateur. Deuxièmement, la relation entre demandeur et participant dans un contexte d'idéation et dans la littérature consacrée au *crowdsourcing* peut être comparée à la relation utilisateur-développeur dans les logiciels libres (Fitzgerald 2006 ; Hetmank 2014). Afin de mieux comprendre comment ce nouveau modèle de production peut mener à la génération et l'amélioration de la créativité, nous proposons d'étendre notre étude au domaine de l'OSS, en nous focalisant sur les interactions utilisateur- développeur et le lien avec la génération d'idée novatrices. Les corrélations entre outils, acteurs et comportement créatif étant encore sous-explorées, nous proposons d'étudier ce lien plus en profondeur à travers la question de recherche suivante RQ2-Quels sont les meilleurs outils pour récupérer ces idées ?

Dans cette optique, l'article 1 étudie la plate-forme d'idéation en tant qu'outil pour améliorer l'innovation et l'article 2 explore les facteurs qui mènent à une performance des OSS, créant un support précieux pour la génération des idées.

Article 1 Comme expliqué précédemment, ce papier a pour but d'explorer le profil du *lead user* dans un contexte en ligne. Par conséquent, cette étude fournit également un domaine pertinent pour répondre à la question associée à l'axe 2 en explorant de quelle manière cette boîte à outils peut aider les utilisateurs/participants à générer des idées novatrices. En effet, le contexte de

recherche de ce papier est organisé autour d'une plate-forme d'idéation que nous avons précédemment développée pour atteindre des objectifs professionnels. En suivant les recommandations des recherches antérieures concernant le *crowdsourcing*, nous avons lancé un défi d'idéation, en demandant aux participants d'« inventer la prochaine génération de tablettes ». Nous mettons également en place des conditions spécifiques afin d'améliorer les interactions entre participants (votes, commentaires...). Les observations du comportement des participants et les interrogatoires poussés nous permettent de démontrer que les interactions au sein des participants autant que les motivations liées à un défi représentent des conditions pertinentes pour la génération d'idées créatives.

L'Article 2 (recherche quantitative) a pour titre « OSS popularity : understanding the relationship between user-developer interaction, market potential and development stage ». Des versions antérieures ont été présentées lors des conférences *Association Information et Management* (AIM) (2016) et *Academy of Management* (AOM) (2015). Ce papier est depuis Septembre 2016, à la troisième étape du processus de relecture après une soumission à *Systèmes d'Information et Management.*

La relecture de la littérature étudiée dans l'axe 2 nous a permis d'identifier de nombreux défis en rapport avec la performance des OSS et le besoin de comprendre la nature des interactions utilisateurs- développeur en tant que vecteur des innovations (Wagstrom 2005 ; von Krogh & von Hippel 2006). Ce papier analyse donc des données provenant de 657 projets OSS provenant de la base de données de SourceForge afin d'étudier la question suivante : l'effet combiné de l'interaction entre utilisateur et développeur et le potentiel commercial mène t-il à une plus grande popularité des OSS ? Nos résultats montrent que le flux d'information reflétant la quantité et la nature des interactions développeur- utilisateur expliquent principalement la popularité des OSS. En d'autres termes, l'outil OSS représente une plate-forme pertinente pour améliorer le comportement créatif et attirer des utilisateurs supplémentaires.

L'Axe 3 a pour but d'étudier le procédé lié à l'optimisation du processus d'innovation. Comme nous nous sommes précédemment focalisés sur qui sont les acteurs novateurs et comment interagir avec eux, nous proposons ici d'étudier plus en profondeur le processus global permettant de rassembler des idées novatrices, mais également d'en chercher un qui soit optimal. Lorsque les

compagnies décident d'externaliser la recherche d'innovation, elles s'attendent souvent à trouver des solutions à des problèmes spécifiques (Franke et al. ; Thomke & Fujimoto). Nous suggérons alors de nous concentrer premièrement sur la littérature consacrée à la résolution des problèmes pour comprendre ce processus. Par conséquent, nous avons exploré le processus de résolution des problèmes et examiné les différentes étapes et défis associés. Les universitaires suggèrent en particulier que les entreprises sont souvent confrontées à des difficultés de formulation des problèmes, en transmettant des informations imprécises ou incomplètes aux solveurs de problèmes (e.g. Maheswaran & Meyers-Ievy 1990 ; Cowan 1990 ; Sitkin & Weingart 1995, Tyre & von Hippel 1997). Il en résulte que lorsque les entreprises décident de sous-traiter les solutions, la première étape est de gérer la transformation de l'identification d'un problème interne en une formulation claire pour des solveurs externes. La théorie de la paire besoin- solution suggère qu'il est possible de résoudre un problème sans passer par l'étape de formulation (von Hippel & von Krogh 2016). Cette théorie manque cependant d'un bagage à la fois empirique et théorique à cause de sa relative nouveauté. De plus, des travaux de recherche antérieurs ont mis en évidence que, alors que le *crowdsourcing* représente une technique pertinente de résolution des problèmes, il reste difficile pour les entreprises de récupérer de la valeur à partir de solutions externes (Bloodgood 2013). En d'autres termes, même si les compagnies collectent des solutions innovantes, le processus permettant à celles-ci de gagner une différentiation compétitive à travers les innovations est encore sous-exploré (Peppard et al. 2011). Dans le but de d'étudier comment les entreprises peuvent vraiment bénéficier de trouver des solutions externes et optimiser le processus externe de résolution des problèmes (Prahalad & Ramaswamy 2004b), nous proposons d'explorer plus en profondeur les méthodes d'externalisation d'un problème à travers la question de recherche suivante : RQ3 : Quelles sont les meilleures méthodes pour récolter des entrées innovantes ? Dans cette optique, l'article 3 vise à expliquer de manière conceptuelle tout d'abord pourquoi et quand les entreprises doivent formuler ou non un problème pour optimiser la recherche des solutions, et deuxièmement comment ce processus peut permettre la récupération de valeur à partir de ces solutions.

L'Article 3 (recherche conceptuelle) a pour titre « Formulate or not formulate : solving problems with a dynamic capabilities perspective ». Une version antérieure a été présentée à la conférence *Annual Open and User Innovation* (OUI) (2015). Cette étude a pour objectif de répondre aux

défis identifiés dans l'axe 3, à savoir les méthodes d'optimisation et le processus de récupération de valeur durant le processus de résolution externe des problèmes. Nous proposons dans ce papier de construire un cadre théorique afin de répondre à la question de recherche suivante: comment et pourquoi les organisations doivent formuler le problème, ou ne pas le formuler ? Notre raisonnement est construit dans un contexte de *crowdsourcing* et nous explorons cette question en nous basant sur un point de vue de la théorie évolutionniste appliqué à la fois à la formulation du problème et aux paires besoin-solution. Nous avons expliqué la complémentarité entre ces deux processus en nous basant sur la théorie évolutionniste (Staw 1990) des idées afin d'optimiser la recherche de solutions. Après une analyse approfondie de la littérature existante, nous avons abouti à la conclusion que nous devons considérer l'idée comme unité d'analyse. Nous avons ensuite couplé l'analyse de la littérature avec les observations d'un défi expérimental d'idéation et soutenons que l'optimisation des solutions pourrait venir du processus de progression de l'idée parmi les participants durant la phase de génération de l'idée (Mainemelis 2010).

De plus, dans le but d'expliquer le processus de récupération de valeur dans notre contexte spécifique, nous avons basé notre raisonnement sur la vision de Teece (2007) des capacités dynamiques (DC) et proposons que le processus d'élaboration de l'idée doit être couplé avec une approche DC afin d'optimiser la recherche de solutions optimales dans le processus de résolution des problèmes. Finalement, nous proposons un modèle conceptuel expliquant (1)le processus itératif entre PF et NSP et (2)les conditions spécifiques dans lesquelles une entreprise pourrait formuler ou non un problème dans le but d'optimiser et de gagner de la valeur à partir des solutions potentielles.

Contributions principales

Notre travail de recherche se positionne à l'intersection des littératures portant sur les systèmes d'Information et d'Innovation. En étudiant trois niveaux d'analyse, à savoir acteurs, outils et méthodes, nous apportons notre contribution pour le développement de la connaissance de chaque théorie mobilisée dans ces domaines. Premièrement, nous offrons de nouvelles idées pour contribuer à la théorie du *lead user* en étendant les travaux de recherche antérieurs d'un contexte hors ligne à un contexte en ligne afin de fournir une première typologie de la construction du *lead*

user connecté. Deuxièmement, nous renforçons la connaissance des théories sur la performance des logiciels libres, en explorant la nature des interaction utilisateur/développeur et leur impact sur la popularité des OSS. Finalement, nous contribuons à mieux comprendre le processus global de résolution de problèmes étudié dans un contexte externe, en proposant un modèle conceptuel expliquant de quelle manière les entreprises peuvent optimiser et récupérer des bénéfices en sous-traitant un problème. Ces contributions seront discutées plus loin dans la section consacrée à la discussion générale, à la fin de ce document.

Axe 1 - Les acteurs en tant que source d'innovation

L'introduction de nouveaux produits sur le marché est traditionnellement le fruit du travail de concepteurs professionnels à qui revient la responsabilité de la conception des produits pour les consommateurs. La participation du client était limitée aux sondages, interviews ou autres outils de marketing pour collecter des informations simples ou des avis (Griffin & Hauser, 1993). Plus récemment, de nombreuses industries ont développé beaucoup de nouveaux produits qui n'ont pas été mis au point par les concepteurs travaillant pour les compagnies mais plutôt par les utilisateurs eux- mêmes (Schreier et al. 2012 ; von Hippel, 2005). Les entreprises ont compris

depuis longtemps que les besoins de l'utilisateur et du consommateur sont importants à prendre en compte, cependant ceci n'est pas en train d'évoluer vers un phénomène de reconnaissance des consommateurs en tant que partenaires actifs (Prahalad & Ramaswamy 2004a). En plus de prendre en compte l'opinion des consommateurs, les compagnies ont tendance à externaliser totalement le processus de développement du nouveau produit. Les exemples concrets de produits novateurs conçus par les consommateurs sont nombreux. Des entreprises commerciales hautement considérées comptent de plus en plus sur les consommateurs pour rassembler de nouvelles idées et créer de l'innovation, telles que Starbucks, Adidas, Dell ou IBM et obtiennent potentiellement de nouvelles idées à des coûts relativement réduits (Huang et al. 2014). Un autre exemple de réussite est le cas de Threadless. L'entreprise de t-shirts basée sur Internet utilise une plate-forme de compétition en ligne afin de sous-traiter le processus du design de leurs t-shirts. En moins d'un an, la compagnie a atteint une marge bénéficiaire de 35 % et était prête à tenter les 18 millions de dollars en 2006 avec moins de vingt employés (Howe, 2008). Ce type d'exemple montre l'importance et les bénéfices de se focaliser sur les utilisateurs en tant que source d'innovation puissante. Il en résulte que le mouvement de co-création devenait de plus en plus attractif pour les entreprises pour rassembler l'innovation. La co-création est définie comme la création de valeur par des communautés d'individus ou de consommateurs produisant de la valeur marchande bénéficiant économiquement à l'entreprise (Zwass 2010).

Pour mieux comprendre ce mouvement de co-création, les chercheurs ont développé des théories de l'innovation par l'utilisateur et ont communément soutenu que les utilisateurs innovent car les produits existants disponibles sur le marché ne répondent pas à leurs besoins de manière adéquate (von Hippel, 1986, 1988). En effet, lorsque les utilisateurs ne sont pas entièrement satisfaits par un produit, ils ont tendance à tenter de répondre eux-mêmes à ce besoin en complétant, améliorant ou même inventant de nouvelles fonctionnalités ou un nouveau produit. Ce phénomène est particulièrement observé dans des secteurs spécifiques tels que les équipements médicaux, les équipement de sports extrêmes, les instruments scientifiques et les outils informatiques (Franke et al. 2006 ; Lilien et al. 2002 ; Morrison et al. 2000 ; Morrison et al. 2004 ; Luthje 2004). Cette spécificité trouve ses origines dans les activités entrepreneuriales dans lesquelles les individus trouvent leurs propres solutions pour satisfaire leurs besoins, mais les entrepreneurs n'ont pas toujours réalisé à ce stade que les besoins auxquels ils cherchaient à

répondre étaient vastes et qu'un marché pouvait être créé en y répondant (Bhave, 1994). Les innovations participatives ont alors tendance à avoir un énorme impact sur le marché de masse et être mieux perçues par les consommateurs avec un impact commercial plus important (Franke et al. 2006). Cependant, et malgré le fait que les bénéfices de l'innovation participative sont pleinement reconnus, les universitaires soutiennent qu'il y a une nécessité de mieux comprendre le processus liant les individus novateurs, le comportement créatif et l'innovation elle-même. En effet, des travaux de recherche antérieurs ont révélé « *des découvertes contradictoires concernant la nature des clients impliqués, et des canaux de communication qui permettent la co-création*» (Mahr et al. 2014).

Il en résulte que ce nouveau phénomène mène à l'émergence de nombreuses questions, concernant à théorie et pratique :

- qui sont ces co-créateurs ?

- comment récupérer les plus créatifs ?

- comment transformer une idée potentielle en un produit innovant sur le marché ?

En effet, la transformation de ce processus d'innovation global soulève d'importantes questions pratiques et théoriques auxquelles les universitaires ont besoin de répondre afin de mieux comprendre les phénomènes de co-création et d'innovation participative. Les premiers éléments de réponse ont émergé de la recherche concernant les « sources d'innovation » car les universitaires reconnaissent le besoin de comprendre à nouveau l'origine même d'une idée novatrice dans le processus d'innovation. Von Hippel (1986, 1988) propose que les utilisateurs qui sont (1)au-delà d'une tendance importante du marché et (2)s'attendent à des bénéfices élevés venant de l'innovation ont plus tendance à développer des innovations attractives. La théorie du *lead user* représente une réponse prometteuse à la question de la différence entre les utilisateurs qui trouvent ou non des innovations attractives (Schreier & Prügl 2008). En dépit des énormes investigations menées sur la théorie du *lead user* (e.g. Franke et al., 2014 ; Franke and Shah, 2003 ; Magnusson et al., 2014 ; Urban and Hippel, 1998), des travaux de recherche récents ont noté que même si cela permet de mieux comprendre les profils des innovateurs, les chercheurs ont besoin de se focaliser sur les caractéristiques du *lead user* (e.g. Jensen et al. 2014). Les *lead*

users sont en effet considérés comme des sujets rares et des caractéristiques additionnelles pourraient être utilisées pour identifier les différents types de *lead users* (Schreier & Prügl 2008). De plus, il semble que la nature du *lead user* dépend également du contexte. Par exemple, selon les secteurs d'activité, l'environnement ou les pratiques de la communauté, les *lead users* pourrait évoluer ou présenter des caractéristiques différentes.

Par conséquent, nous cherchons à apporter notre contribution afin de souligner la nature des clients novateurs et étudier de manière plus approfondie leur comportement créatif dans différents contextes spécifiques. Dans la prochaine partie de cette section, nous présentons et définissons dans un premier temps le concept d'innovation participative et deuxièmement le contexte spécifique du *lead user*. Nous identifions ensuite des défis pour la recherche et le positionnement de notre travail.

Axe 2 - Les outils en tant que moyen de co-créer

Alors qu'il est à présent admis que les entreprises comptent sur des utilisateurs externes pour encourager l'innovation, un nouveau paradigme pour permettre des innovations organisationnelles fait son émergence. Ce paradigme est appelé *crowdsourcing* par Howe (2006) et défini comme un type d'activités participatives engageant un grand groupe d'individus à accomplir volontairement une tâche dans un but prédéterminé (Majchrzak & Malhotra 2013). De nombreux succès pratiques ont poussé les chercheurs à s'intéresser au phénomène de *crowdsourcing* afin de mieux comprendre son fonctionnement, ses enjeux et les implications pour la théorie et la pratique. Par exemple, Dell (en Février 2007) a lancé une initiative d'appel ouvert i.e. IdeaStorm, une plate-forme d'idéation qui permet aux individus sur toute la surface du globe

de poster leurs idées ou leurs commentaires. La compagnie invite les utilisateurs à améliorer un produit où à répondre à des problèmes spécifiques à travers sa propre plate-forme en ligne. Il en résulte que Dell a implémenté près de 200 des quelques 10.000 idées qui ont été postées sur IdeaStorm (voir IdeaStorm.com).

Ce succès démontre l'importance des outils collaboratifs pour encourager et faciliter les nouvelles formes d'activités interactives (Majchrzak & Malhotra 2013), et suscite de vifs intérêts dans la recherche universitaire. Premièrement, il y a un besoin d'explorer les spécificités du comportement des participants (Lakhani & von Hippel 2003), savoir comment la connaissance est créée (Franzoni & Sauermann 2014), et de manière plus importante comment les idées créatives ressortent du *crowdsourcing* (Toubia 2006). Deuxièmement, les universitaires avaient pour objectif de se concentrer sur les différentes méthodes et techniques qui permettent de sous-traiter un problème. En effet, des recherches antérieures démontrent que les boîtes à outils pour l'innovation participative ne sont pas seulement développées pour quelques types de produits industriels spécifiques, mais pourraient servir comme une méthode précieuse de développement des nouveaux produits pour tous types de produits ou services (von Hippel & Katz 2002).

Par conséquent, l'émergence du phénomène de *crowdsourcing* met en évidence de nombreux enjeux concernant à la fois les acteurs et les outils :

- comment le *crowdsourcing* permet-il la génération d'idées ?

- quels sont les outils qui permettent de rassembler les idées ?

- comment les outils peuvent-ils mener à l'amélioration de la créativité ?

La plupart du temps, le développement des nouveaux produits se fait selon un processus stage-gate, en commençant par la phase de génération des idées, suivie par l'implémentation des idées et s'achevant sur le lancement du nouveau produit. À travers ces différente phases, la compagnie travaille avec des directives spécifiques pour traverser les *gates* (Salter et al. 2014). L'utilisation des techniques de *crowdsourcing* a cependant remis en question la manière dont le processus de génération d'idée est considéré, vu que cela redéfinit totalement le modèle d'innovation, le faisant passer de fermé à ouvert (Chesbrough 2003) en invitant des individus à externes à produire des

idées. La première question est reliée à cette préoccupation.

La deuxième question traite des moyens qui permettent la recherche d'innovation via les techniques de *crowdsourcing*. Pour répondre à cette question, la littérature portant sur l'innovation propose qu'une approche boîte à outils puisse être considérée. L'approche boîte à outils pour le développement des produits et des services implique de transférer les tâches de développement de produits liées aux besoins des constructeurs aux utilisateurs (von Hippel & Katz 2002), via des outils virtuels. De nombreux outils basés sur le net ont été montrés comme facilitant l'innovation et permettent des formes d'interaction variées. Nous nous concentrons ici sur deux outils différents : le logiciel libre (OSS) et la plate-forme d'idéation. Ces choix découlent des succès pratiques qui augmentent considérablement l'intérêt des chercheurs pour ces outils. Nous avons mentionné auparavant les cas de Dell et de la plate- forme IdeaStorm pour démontrer l'efficacité des plates-formes d'idéation, et d'autres exemples viennent renforcer cette hypothèse. Paal Smith-Meyers, chef du *New Business Development* chez LEGO, a expliqué que 90 % de leurs clients désirent des produits personnalisés. Même si seulement 1 % d'entre eux ont les compétences requises, avec une base de consommateurs de 32 millions de personnes, cela représente plus de 3000 individus qui peuvent potentiellement développer des idées novatrices (Jensen et al. 2014). Avec la plate-forme d'idéation LEGO design (lancée en 2008), la compagnie a testé la vente de produits entièrement conçus par les clients. Les plate-formes d'idéation représentent donc un « partenaire » très intéressant pour le rassemblement des idées et les interactions avec des utilisateurs novateurs potentiels.

De plus, les logiciels libres sont également représentatifs des récents succès basés sur le web. Depuis de nombreuses années, les OSS ont été largement adoptés pour atteindre différents objectifs. Par exemple, le succès d'Apache avec plus de 65 % des sites publics utilisant ce serveur web (von Krogh 2003) ou Linux avec près de 40 % des grandes sociétés Américaines se servant ce système d'exploitation (Bagozzi & Dholakia 2006), représentent des défis à la fois universitaires et de management. Finalement, nous avons vu dans la section précédente que les *lead users* sont utilisés comme clients/utilisateurs actifs fournissant des idées novatrices. Nous n'avons cependant que peu d'informations concernant la manière dont ces sujets réagissent dans ce contexte connecté spécifique et comment les outils basés sur le web permettent de détecter ou même augmenter le caractère novateur des utilisateurs.

Les partie suivantes sont par conséquent consacrées à, premièrement, définir le concept de *crowdsourcing* pour promouvoir la génération d'idées, et deuxièmement les outils identifiés – plate- forme d'idéation et OSS - en tant que moyens de sous-traiter un problème et d'améliorer l'innovation participative. Troisièmement, nous développons les défis de recherche sous-jacents et finalement, nous présentons nos contributions à ces défis au travers de deux études.

Axe 3 - Les méthodes pour optimiser le processus d'innovation

Dans cette partie, nous présenterons tout d'abord l'intérêt d'étudier les méthodes d'optimisation du processus d'innovation. Deuxièmement, nous proposons de présenter et définir les concepts du processus de résolution des problèmes et celui de paire besoin-solution. Finalement, nous identifierons les défis pour la recherche et présenterons notre contribution aux réponses à ces défis à travers l'étude 3.

Ces deux premiers axes étaient dédiés à l'explication des rôles des acteurs et des outils numériques (i.e. plate-forme d'idéation et OSS) dans la recherche de solutions externes. Nous avons étudié les manières d'utiliser les outils et les acteurs pour augmenter les chances d'une entreprise d'influencer les idées novatrices. En d'autres termes, nous nous sommes focalisés sur le

processus d'innovation en enquêtant tout d'abord sur comment les utilisateurs peuvent générer des idées créatives (Axe 1) et deuxièmement sur comment les outils peuvent faciliter les interactions entre les utilisateurs eux-mêmes et entre les utilisateurs et les compagnies (Axe 2). Cependant, avant d'externaliser un problème, les entreprises doivent d'abord identifier et formuler celui-ci dans le but de définir la manière de le résoudre (Volkema 1983 ; Afuah & Tucci 2012). Néanmoins, de nombreuses entreprises travaillent souvent sur le mauvais problème, car elles n'ont pas défini celui-ci de manière adéquate. Spradlin (2012) explique que « quand elles développent de nouveaux produits, la plupart des compagnies ne sont pas suffisamment rigoureuses dans la définition des problèmes qu'elles tentent de résoudre et l'explication de pourquoi ces problèmes sont importants ; et, sans cette rigueur, les organisations ratent des opportunités, gâchent des ressources et finissent par mener des initiatives d'innovation. Ayant compris et reconnu l'importance de définir et de formuler un problème, les chercheurs ont largement exploré le processus global de résolution de problèmes pour aider les compagnies dans la recherche de la solution. Le processus de résolution des problèmes est communément décrit comme une succession d'étapes qui sont : l'identification du problème (Spradlin, 2012), la formulation du problème (Simon 1973 ; Volkema 1983 ; Lyles & Thomas 1988) et la recherche des solutions (Lang et al. 1978).

De plus, les travaux de recherche théoriques et empiriques ont communément montré que la formulation du problème (PF), par laquelle les visions alternatives d'un problème sont générées et sélectionnées afin de construire la formulation d'un problème, représente un premier stade critique du processus de résolution du problème. En effet, la difficulté principale de formuler le problème a été précisée par Simon (1973), qui trace une distinction cruciale entre les problèmes bien structurés et mal structurés, expliquant que seuls les problèmes structurés correctement sont adaptés à une solution algorithmique.

Tandis que de nombreux travaux de recherches se sont intéressés à l'amélioration du processus de formulation de problèmes (e.g. Sheremata 2000; Atuahene-Gima & Wei 2011; Becker et al. 2005), une théorie récente a émis l'idée que les solutions pourraient être découvertes sans formuler de problème. En effet, von Hippel & von Krogh (2016) exposent que, dans le processus informel de résolution de problème, un besoin et une solution sont souvent découverts ensemble. Ils ont soutenu que la découverte d'une paire besoin/solution (NSP) viable pourrait avoir des

avantages par rapport aux méthodes initiées par la résolution de problèmes, et fournit des solutions plus novatrices dans certaines circonstances.

Les auteurs tirent parti de l'idée selon laquelle la résolution des problèmes consiste à faire un lien entre un point spécifique dans l'espace des besoins et un point spécifique dans celui des solutions et ensuite d'appeler ces points liés une « paire besoin/solution ». En d'autres termes, ils soutiennent que dans la vraie vie, selon l'environnement spécifique, les solutions apparaissent souvent avant d'avoir identifié le bon problème.

Cependant, à cause du caractère récent de leur positionnement, von Hippel et von Krogh (2016) reconnaissent que les chercheurs ont encore à apprendre et peuvent travailler dans différents contextes et gouvernances, et suggèrent que les universitaires devraient mener des recherches pour comprendre les principes associés à son fonctionnement. En effet, il n'existe pas aujourd'hui d'études pour soutenir ni la théorie ni la pratique de la résolution des problèmes via l'identification des paires besoin/solution. Par conséquent, ce nouveau phénomène mène à l'émergence de plusieurs questions, avec à la fois des préoccupations théoriques et de management:

- comment les compagnies peuvent-elles optimiser le processus de formulation des problèmes (PF) ?
- comment définir le processus de NP dans un environnement concret ?
- comment les compagnies peuvent-elles influencer les innovations du processus de découverte NSP ?

À travers ces questionnements, nous identifions le besoin d'améliorer notre connaissance du NSP d'un point de vue à la fois théorique et de management. En effet, nous avons d'abord besoin de comprendre plus en profondeur de quelle manière le phénomène NSP est applicable dans les compagnies. Alors que von Hippel et von Krogh (2016) soutiennent que la NSP a le potentiel de surmonter les difficultés de la formulation d'un problème, ils reconnaissent également la nécessité de cadres bien établis expliquant le fonctionnement du NSP. Les auteurs ont en effet positionné leur travail à l'opposé des méthodes de résolution de problèmes. En pratique, les compagnies doivent cependant comprendre comment le rendre possible dans un contexte de gestion. Nous proposons donc dans un premier temps d'identifier et déterminer le cadre théorique par lequel

cette méthode pourrait être applicable. Dans un deuxième temps, nous cherchons à déterminer les différences entre les processus NSP et PF dans le but d'expliquer comment les compagnies devraient « choisir » le meilleur moyen d'aborder un problème. Finalement, nous avons observé précédemment que les compagnies visaient à générer des solutions novatrices pour répondre à un problème. Nous proposons donc d'étudier de quelle manière la méthode NSP pourrait aider les entreprises à rassembler les idées les plus novatrices. Dans le but de répondre à ce problème, nous soutenons que nous avons besoin de considérer l'idée en tant qu'unité d'analyse pour comprendre le processus de progression des idées durant leur génération, et comment les méthodes pourraient influencer l'émergence du comportement créateur (Mainemelis 2010). Les deux premières sections de notre travail de recherche étaient consacrées à répondre à la question de « pourquoi ouvrir » la recherche des solutions (Afuah & Tucci 2012) et « où chercher » les solutions novatrices (Lopez-Vega et al. 2016). Le but de cet section est de répondre à la question « comment chercher » les solutions novatrices, et plus spécifiquement quelles sont les meilleures méthodes (i.e. NSP/formulation du problème) pour récupérer les solutions les plus novatrices.

Conclusion Générale

Ce travail de thèse aborde le problème fondamental des déterminants de l'innovation participative dans le processus d'innovation, pour la génération de nouvelles idées dans un environnement numérique. Ce travail de recherche se base sur différents sujets exposés dans la littérature : Innovation, Systèmes d'information et résolution des problèmes. Au lieu d'étudier ces volets de recherche de manière indépendante, nous avons précautionneusement tenté de comprendre leur lien avec l'apparition du comportement créateur. Ces corrélations entre ces trois niveaux viennent de l'idée que des mécanismes sous-jacents d'innovation ouverte regroupent différentes formes de manifestations avec de nombreux niveaux d'individus, d'organisations et d'environnements (Felin and Zenger 2014). En accord avec cette vision, nos découvertes montrent clairement un besoin de lier les acteurs, les outils et les méthodes afin d'améliorer la probabilité des entreprises de récupérer des solutions optimales à partir de sources externes. De manière spécifique, notre travail de recherche montre que la génération d'idées nouvelles et utiles par les individus (les acteurs) est grandement influencée par l'environnement (les outils numériques) et les manières d'aborder un problème (les méthodes). Cette perspective offre un cadre intégratif qui semble être particulièrement utile pour clarifier la complexité du paradigme de l'innovation ouverte

(Chesbrough 2004). En utilisant cette perspective, ce travail de recherche contribue à faire progresser la connaissance de ces trois volets de recherche comme suggéré dans la section consacrée à la discussion.

En particulier, cette dissertation améliore la connaissance des théories de l'innovation participative, en explorant plus en profondeur le concept de *lead user* et fournit une typologie de leur profil dans un contexte connecté. Ce travail contribue également à la littérature traitant du *crowdsourcing* en étudiant de quelle manière un environnement numérique pourrait permettre la génération d'idées, à savoir la conception des outils numériques, tels que les plate-formes d'idéation et les logiciels libres.

Finalement, ce travail de recherche permet d'identifier les méthodes les plus prometteuses pour changer un problème interne en un défi attractif pour la foule. Cette étude contribue à la littérature traitant de la résolution des problèmes en proposant un modèle conceptuel traitant de quand formuler ou non le problème, en fonction de nombreux facteurs. Ce modèle fournit également des idées intéressantes concernant le sujet sous-exploré de comment les organisations peuvent récupérer de la valeur à partir du *crowdsourcing* (Bloodgood 2013 ; Lepak et al. 2007), en utilisant le point de vue de la capacité dynamique de l'évolution des idées.

Ce travail de recherche n'est cependant pas exempt de limitations, qui ont été mises en évidence dans la section consacrée à la discussion. En particulier, tandis que ce travail de recherche se focalise principalement sur des facteurs externes, il est nécessaire de mieux explorer les facteurs individuels dans l'environnement numérique en tant qu'antécédents de la créativité. Parce que la créativité est nécessaire mais insuffisante pour le développement de l'innovation (Carayannis & Gonzales 2003), cette perspective pourrait permettre une meilleure compréhension de comment le comportement créateur dans un tel environnement pourrait mener à la production d'idées innovantes, et avoir un impact sur la performance des entreprises.

Cette perspective démontre également une nécessité de poursuivre l'investigation des antécédents et des implications de l'innovation, à travers les multiples possibilités d'approcher et de comprendre le paradigme de l'innovation ouverte.