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Tesis doctoral

New paths to external collaboration in new product development projects

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New paths to external collaboration in new product development projects

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Declaration

I certify that the thesis I have presented for examination for the PhD degree of the Universitat Internacional de Catalunya is solely my own work other than where I have clearly indicated that it is the work of others (in which case the extent of any work carried out jointly by me and any other person is clearly identified in it).

I warrant that this authorization does not, to the best of my belief, infringe the rights of any third party.

Abstract

According to the strategic management, open innovation, and project management literatures, the notion that SMEs can enhance their innovation ability by developing knowledge resources has become important for achieving competitive advantage and long-term survival. Building upon theoretical work on the resource-based view, contingency theory and open innovation literature, this research examines how project complexity contribute to implementation of open innovation practices and involving external knowledge sources in different phases of new product development (NPD).

The conceptual model was developed and aims to answer three important questions. RQ1: How complexity contributes in strategic decision for external collaboration in NPD process? RQ2: How external collaboration can improve internal capabilities and reduce the level of project complexity? RQ3: How collaboration with external knowledge source can improve new product performance? This study examines the four open innovation practices: Partnership, Seller/ Buyer agreement, Community and platform, and four knowledge resources: Suppliers, Customers, Universities and Competitors that impact a firm's innovation process and affects the project performance.

The model is tested with data collected from 125 new product development projects in 85 Spanish low knowledge intensive SMEs.

The empirical result shows that project complexity contributed to the development of open innovation practices in new product development projects. The result specified that partnership as the dominant mode of open innovation practices will implements in different phases of the projects to reduces the level of project complexity and improve absorptive capacities of the companies. The results also found that to achieve different dimensions of the project performance, the companies have to use different configurational paths to involve external knowledge sources in each phase of NPD projects. Therefore, these findings conclude that implementing open innovation practices and involving external knowledge sources in innovation process, does not follow the same path, where project complexity, internal absorptive capacity and phases of the projects are the factors which make difference in this configurational models.

This research has noteworthy implications for both researchers and practitioners by (1) Developing an integrated framework of project complexity in open innovation context. (2) Providing guidelines

for low knowledge intensive SME's in developing open innovation practices in their NPD projects. (3) The open innovation literature needs to consider empirically how knowledge resources involved in different phases of projects and enhance the project performance. (3) Indicating that the configuration of the different knowledge resources in different phases of NPD projects, leads to the different dimensions of the project performance (Speed, Cost, Market and product novelty) for SME in the low- technology industry. Limitations in current research may create avenues for future research in terms of number of companies, methodologies, open innovation modes, innovation types and time.

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Abbreviations

NPD	New Product development
OI	Open Innovation
OIP	Open Innovation Practices
KS	Knowledge Source
fsQCA	Fussy set Qualitative Comparative Analysis
SCM	Supply Chain Management
T	Technical complexity
O	Organizational complexity
E	Environmental complexity
I	Interaction (Inter-organizational) complexity

Chapter 1

Introduction

1. Introduction

Business environments and customer needs are changing rapidly, making innovation essential for businesses to survive in the marketplace (Bhaskaran, 2006). However, SMEs face several challenges in differentiating their products and services from their competitors. SMEs do not have enough financial and technical capacity to effectively integrate innovation into their business models (Hitchen et al., 2017). Therefore, they must collaborate with external partners to innovate successfully, develop new sources of revenue and increase their profitability relative to their competitors (Ahn et al., 2015). Open innovation (OI) is therefore a logical step that many SMEs must undertake (Vanhaverbeke et al., 2012). This applies to entities of all sizes and in all sectors, and the key question to resolve according to Chesbrough (2003a) is: how do companies manage the complex innovation process? In recent years, OI's focus has grown and has been discussed by both researchers and professionals (Dahlander and Gann, 2007). "OI is a paradigm that assumes that companies can and must use external ideas, as well as internal ideas and internal and external paths to the market, because the company is seeking to advance its technology," is the definition proposed by Chesbrough (2003a): is considered the founder of this approach.

Therefore, OI represents the mentality of moving from a closed approach to internal research and development (R & D) to a much broader innovation model in which ideas, knowledge, and internal and external technologies are combined to develop new products and technologies and organizational services. (Laviolette et al., 2016). Cooperating actors and networks are represented, for example, by customers, competitors, suppliers and research institutes that can drive and improve a company's innovation process (Chesbrough, 2003a, Eggers et al.., 2018). Over the years, based on the growing research in this area, Chesbrough and Bogers (2014) have published an updated definition that describes OI as a "distributed innovation process [...] based on knowledge flow, intentionally managed across organizational boundaries and using pecuniary mechanisms consistent with the organization's business model.

In addition to internal R & D activities, companies are also constantly confronted with new technologies and new knowledge of their environment (Jones et al., 2014). Also, organizations can also open their innovation process by referring to the use of outbound OI when the company markets ideas or technologies developed in-house with external partners (Huizingh, 2011). These knowledge flows can also be combined within the enterprise by joining external sources of knowledge and also conducting marketing activities (Chesbrough and Bogers, 2014). While in the 20th century, the closed innovation approach prevailed, indicating that innovation had to be controlled within the firm (Ham et al., 2017). In this context, the company creates, develops and markets its own ideas. The mobilization of labor and the increase in private venture capital have led to changes in the behavior of innovation. According to the new OI model, companies, according to Chesbrough (2003b), market not only their own internal ideas, but also the innovations of external partners to commercialize them by designing ways out of the organization's current activities.

The remainder of this Introduction will first provide the PhD project description. Section 1.1, will subsequently give a brief background of the implementation of open innovation practices in Small and

Medium size enterprises (SMEs). Section 1.2, will explain about the importance of project phase level as a relevant unit of analysis in open innovation and project management context. In section 1.3 we are introducing project complexity as an important factor in project management and developing strategic collaboration during NPD projects but receive little attention in the open innovation literature. Section 1.4 will explain the theoretical background of this thesis. Section 1.5 state the objectives of this work, research questions and significance of the thesis, while Section 1.6 will deal with methodological considerations. Finally, Section 1.7 will provide an outline of the Chapters that follow.

1.1-Open innovation in SMEs

Existing OI research is largely directed at large firms, particularly high-tech industries, although a growing number of non-industry firms are the first to adopt (Chesbrough, 2003a). As a result, the scope is no longer limited to high-tech industries, but extends to more traditional and mature industries (Chesbrough and Crowther, 2006). The actual influence factors and their concrete effects on innovation activities in small and medium-sized enterprises (SMEs) and new firms receive little attention in the literature (Lee et al., 2010, Grimsdottir and Edvardsson 2018, Bigliardi and Galati 2018). However, an increasing number of studies of these types of businesses demonstrate the relevance of an IO approach to improving the overall performance of innovation (Hossain and Kauranen, 2016).

SMEs are defined differently in the world (Ayyagari et al., 2007, Grimsdottir and Edvardsson 2018). According to the European Commission (2016), SMEs are companies with less than 250 employees whose annual turnover does not exceed 50 million euros or whose total assets does not exceed 43 million euros. If published statistics on SMEs are observed, their overall relevance is obvious. In general, 99% of EU companies can be classified as SMEs (European Commission, 2016, Grimsdottir and Edvardsson 2018). However, compared to larger firms, SMEs face different structural conditions that result in restrictions because of their size, scarcity of resources and limited technological assets (Jones et al., 2014, Woschke et al., 2017). Therefore, it is essential to specifically address the SME sector with its characteristics, as the implementation of the OI can be an opportunity for SMEs to overcome the challenges mentioned above. Previously, Spithoven et al. (2013) and Brunswicker and

Vanhaverbeke (2015) found that SMEs benefited more from OI activities than large firms. Because SMEs are more willing to take risks and are more results oriented (Dufour and Son, 2015, Parida et al., 2012, Rocheska et al., 2014) than large companies.

SMEs are usually companies where the founders want to keep control. Clearly, this implies a lack of willingness to disclose information about their innovation processes and, as a result, a lack of willingness to accept transparency (Dufour and Son, 2015, Hernández-Mogollon et al., 2010). SMEs also differ from large companies in terms of organizational structure. In fact, SMEs have a more flexible and organic structure than large firms (Brunswicker and Vanhaverbeke, 2015, Rocheska et al., 2014). In addition, in today's changing environment, while SMEs may find it more difficult to recognize the need for change, their structure encourages innovation and allows them to better adapt to the environment than their larger counterparts (Brunswicker and Vanhaverbeke, 2015). SMEs are less formalized and can generally adjust their processes (Van de Vrande et al., 2009; Brunswicker and Vanhaverbeke, 2015; Lee et al., 2010). The decision-making process is usually centralized at the manager level, which is responsible for many aspects of the business and most management decisions (Dufour and Son, 2015, Zahra and Filatotchev 2004). Similarly, SMEs have a limited number of customers and suppliers. His smallness also encourages individual creativity. As Van de Vrande et al. (2009) pointed out, SMEs often rely on the initiatives of their employees when seeking new methods of innovation. In addition, the innovation models of SMEs differ from those of their larger counterparts: innovation in SMEs is generally external oriented and is largely based on social and personal links (Baum et al., 2000; Vanhaverbeke, 2015, Edwards et al., 2005). Because of their size, SMEs cannot cover all the innovation activities needed to carry out an innovation (Brunswicker and Vanhaverbeke, 2015, Lee et al., 2010).

As a result, innovation in SMEs is almost always characterized by an inter-organizational component that covers boundaries and relies on collaboration with other firms (Brunswicker and Vanhaverbeke, 2015, Edwards et al., 2005, Lee et al., 2010). Among others, the literaryoften proposes their limited resources as the main challenge: SMEs suffer from a lack of human capital, financial resources, managerial and technical skills, as well as know-how and technological assets (Bigliardi and Galati, 2016b; Brunswicker and Vanhaverbeke, 2015; Caloghirou et al., 2004; Dahlander and Gann, 2010; Dufour and Son, 2015; Lee et al. 2010; Oakey, 2013; Rahman and Ramos 2010; 13 Spithoven et al., 2013; van de Vrande et al., 2009; Wynarczyk et al., 2013).

1.2- Open innovation and level of analysis

To a large extent, research in the areas of research strategies and collaborative innovation has focused on identifying the "optimal" number of external partners (Laursen and Salter, 2006), as well as the importance of different types of external sources (Faems et al., 2005). The most notable similarity between these studies is that the analyzes are done at the firm level, which means that research and collaboration are considered a general decision of the company and not a decision based on the requirements of the company specific project to develop new technologies and products (NPD). To our knowledge, only a few have studied the effect of involving different types of external sources at the project level in the context of open innovation (Bahemia and Squire, 2010). The study of external collaboration in innovation and new product development at the project level is very important for the following reasons: firstly, innovation projects are increasingly seen as an organizational unit of the highest importance to boost the performance of innovation (Shenhar and Dvir, 2013) in the organizational framework for R&D activities (Sydow et al., 2004). Second, since the evidence on the sign and magnitude of the effect of external collaboration on the development of new products is mixed (Tsai, 2009, Vanhaverbeke et al., 2014b), the literature recently asked for identification of different factor contingency induced by the different levels of analysis. (Bogers et al., 2017, West and Bogers, 2014).

Vanhaverbeke et al. (2014) state that "a direct reason [for mixed evidence] is that most studies add different project-level practices to general enterprise-level concepts, which are then linked to performance indicators, at the level of the company ". Third, findings from firm-level studies cannot simply be transferred to the project level, as this may obscure a variation in the underlying collaborative decisions and the resulting performance results (Vanhaverbeke et al. al., 1991). 2014b). Since "openness at the firm level is determined by the opening of individual R & D projects" (Kim et al., 2015), the same average measure of collaboration activity at this level can result from a wide range of decisions regarding the breadth and depth of collaboration and the partners involved at the project level.

Given the great importance of collaboration on innovation at the project level, recent research has addressed project-level collaboration with further examination, examining the relationship between the types of individual partners and the performance of projects at the project level (Du et al., 2014, Schleimer and Faems, 2016). However, the effects of the composition of the collaborative portfolio and the activities of this portfolio on the project's performance remain little studied. As far as we know, studies in this area at the project level have been studied since 2013 and the research was conducted by Salge et al. (2013), who find a curve linear relationship between the openness of research and the results of the development of new innovation products. Kobarg et al. (2019), who found inverted U-shaped relationships between the extent of collaboration and performance. radical innovation and between the depth of collaboration and the performance of incremental innovation. Salge et al. (2013) focus on the ideation stage of the project. However, project-level studies benefit from the adoption of a holistic perspective that covers all stages of the project (eg Clarke, 1999, Sommer et al., 2014) and the contributions of collaborative partners, may differ in later phases of the project (Benedetto, 1999, Vanhaverbeke et al., 2014b). Therefore, despite its great relevance to theory and practice, our knowledge of the influence of the breadth and depth of the collaborative portfolio on project performance at the project phase level (and at all stages of the project the projects) is still limited.

Bridging this research gap is relevant for a number of reasons. First, it would improve our understanding of the performance results of external collaboration at the project phase level. Secondly, reducing this gap could provide more information on the reasons for the mixed results regarding the effects of external collaboration on performance in the different phases of new product development. In this context, it could be argued that improving our understanding at the project phase level could improve our understanding of the performance effects of external collaboration in general. As innovation activities within companies are increasingly organized into project organizations (Blindenbach-Driessen and Van Den Ende, 2010), it is likely that project and innovation managers will have to make decisions that shape the business process. and the depth of collaboration of their projects. The challenge here is related to the NPD's analysis at the project phase to contribute to the open innovation literature with a more complete and in-depth view of the relationship between external sources and innovative performance. To do this, we analyze sources and relationships from two additional perspectives. First, by examining the combination of external sources in the different phases of the NDP process and their relationship to project-level performance. Second, we study the nature of the relationship between companies and its privileged partner using the concept of "link force", a concept widely used in network literature (Burt, 1992, Granovetter, 1985, Uzzi, 1996). We suggest that the project's phase-by-phase analysis provide a more real and diverse picture of innovation activities in firms and their effects relative to firm-level or project-level studies (Molina-Castillo and Munuera- Alemán, 2009).

1.3- Complexity in innovation projects and open innovation

The complexity of the project can be understood as "the quantity and heterogeneity of different interdependent elements" (Burke and Morley, 2016). A retrospective look at the challenges and complexities of the project suggests that most of them were rooted in society's decisions to become involved in new (or innovative) techniques and practices often used for the first time. Although strategically justified, it seems that the company needs a better adaptation of the practices of organization and development to the innovation introduced by these decisions. To grasp the richness of the complexity of the project, Bosch-Rekveldt et al. (2011) determine no less than three categories, fourteen subcategories and fifty different elements. Projects are established regularly for the explicit purpose of solving complex tasks (Hobday, 2000). Interdisciplinary teams (Pauget and Wald, 2013), ambiguous objectives and methods (Turner and Cochrane, 1993, Williams, 1999) and the uncertainty of unique and innovative mandates (Geraldi, 2009) add to the complexity of temporary organizations (Geraldi et al., 2011). Hanisch and Wald (2014) emphasize the multiple and dominant effects of the structural complexity of the project team's performance. Encompassing the professional and demographic diversity of the project team and the many interfaces between the project team and stakeholders, the structural complexity increases the demand for information processing and coordination, prevents the establishment of common standards and weakens confidence. and increases the risk of coordination failure. Although complexity is an inherent and defining feature of projects (Burke and Morley, 2016), the effect of complexity on project management performance is not explored empirically. Bakhshi et al. (2016) even argue that complexity is one of the most controversial issues in project management. Therefore, by integrating uncertainty, diversity and heterogeneity, complexity precludes effective collaboration between teams, creating a gap between available and required knowledge (Geraldi et al., 2011). For example, job uncertainty can affect a team's ability to identify and acquire relevant knowledge. Professional and cultural diversity can easily impede the assimilation of team knowledge. Similarly, it is likely that the heterogeneity of actors and the structural complexity will delay the transformation of existing knowledge into new knowledge. Finally, if complexity undermines any process of prior knowledge, the last stage of knowledge exploitation is in danger. As a result, the complexity of the project influences important decisions about the management of the project and its management, ranging from improving the level of internal capacity to the process of prior knowledge through external collaboration with different sources of knowledge.

1.4- Conceptual framework

Collaboration for innovation, ie "co-creation with (mainly) complementary partners through alliances, cooperations and joint ventures where giving and receiving is essential to success" (Enkel et al., 2009), these are mutual innovation activities with shared objectives and active participation between partners and thus represent a different type of open innovation (Enkel et al., 2009). The benefits of open innovation lie in three main conceptual channels. First, from the point of view of knowledge (Grant, 1996, 1997, Nonaka, 1994), collaboration in innovation is associated with the acquisition of knowledge that is not present in the enterprise (Chesbrough, 2003; Baden-Fuller, 1995), for example, information on customer demands, market needs or specialized technological knowledge (Belderbos et al., 2006, Tödtling et al., 2009, Von Hippel, 1994). Collaboration thus expands the available knowledge base for knowledge recombination, which is a key driver of innovation (Conner and Prahalad, 1996, Sood and Tellis, 2005). Second, according to the resource vision (Barney, 1991, Wernerfelt, 1984), collaboration for innovation is a means of accessing resources held by partner organizations (Ahuja, 2000, Wassmer and Dussauge, 2012). and (monetary) risks associated with innovation in uncertain technological environments (Belderbos et al., 2004a, Das and Teng, 2000).

The potentially damaging aspects of collaboration for innovation, in addition to transaction and opportunity cost (eg, Salge et al., 2013), were identified primarily as the risk of over-research, ie to complicate the identification and allocation of resources to valuable sources of knowledge (Laursen and Salter, 2006), which has a negative effect on the performance of innovation (Keijl et al., 2016). We argue that the extent to which these beneficial and damaging effects accumulate in innovation projects depends on the scale and pattern of collaborative activity in these projects. Third, according to configuration theory, which identifies the link between an organizational structure and strategic intent (Hult, Ketchen, Cavusgil and Calantone, 2006). The theory is rooted in earlier studies (Miller, 1996) and suggests that for each individual context, some organizational configurations of strategy and structure will adapt better to others and lead to better performance (Dess and al., 1993). The better the match between structure and strategy, the better the performance (Vorhies & Morgan, 2003). Meyer et al. (1993) explain organizational configurations as any sort of multidimensional constellation of conceptually distinct features that occur together. Instead of looking for similar global relationships in all organizations, this theory suggests that relationships could be better identified with respect to sets of conditions (Vorhies and Morgan, 2003). In addition, an adequate set of variables or conditions will generally not lead to better performance (Doty et al., 1993). Configuration theory focuses primarily on the fact that structural and policy elements generally generate few manageable configurations, Gestalten and archetypes, which represent a large number of successful firms (Miller, 1986, 1996).

1.5- Objectives, questions and significance of the research

Divergent views in the literature on "open innovation" and its different lines of research may indicate that the implementation of open innovation practices to the innovation process is one of the most current topics in the field of innovation and management of knowledge. By observing trends in open innovation research, we can see that there are different new trends with a greater emphasis on practical implementation of the theories that are developing in this literature. Our main objective in this study is to highlight the strategic decision making process of open innovation, which has been the subject of less intensive research but which has a strong impact on innovation, and to develop a configurational path to better innovation performance by participation of external sources of knowledge in the innovation process and more specifically developing new products (NPD) and process. The contribution of this research to the existing literature is to broaden the discussion to the implementation of open innovation practices by shifting the focus from high-tech industries to core industries, from large firms to SMEs, from companies or projects based to projects phases level of the projects sand also the analysis and role of complexity in the strategy development process.

On this understanding, the key objectives and research questions to which this thesis seeks resolution are:

- How complexity does contribute in strategic decision for external collaboration in NPD process?
- How external collaboration can improve internal capabilities and reduce the level of project complexity?
- How collaboration with external knowledge source can improve new product performance?

Figure 1 shows the structural connections for different chapter of this thesis.

Figure 1- Structural format of the thesis

Inputs		Outputs	Unit of analysis
Semi structural Interviews	**Chapter 2**	✓ Project complexity framework ✓ Open innovation practices in NPD projects ✓ Knowledge sources involved in NPD projects	**Project level**
✓ Questionnaire (Absorptive capacity) ✓ Project complexity framework **(from Chapter2)** ✓ Open innovation practices in NPD projects **(from Chapter2)**	**Chapter 3**	Configurational paths to implement partnership as the dominant mode for external collaboration	**Project phase level**
✓ Interview (project performance) ✓ Knowledge sources involved in NPD projects **(from Chapter2)**	**Chapter 4**	Configurational paths to project performance by involving external knowledge sources in NPD projects	**Project phase level**

1.6- Research methodology

This study focuses on the processes and outcomes associated with individual NPD projects rather than the overall product development performance of a company or division; it is necessary to have more details on the results obtained from different strategic collaborations in the different phases of the project.

We have more consideration on gathering more evidence about when and what type of external collaboration may perform the best strategic configurations. To find these configuration routes, the qualitative comparative analysis method (FsQCA), used in most of the analysis of this study.

Spanish companies with low knowledge intensive and at least one NDP project in the last two years in different sectors are considered our sample population for this research. Primary and secondary data sources were collected and the conceptual validity of the data was verified according to the triangulation rules (Greene, 1990). A series of in-depth interviews were conducted with companies (directors and general managers of R & D), in accordance with the process described by Eisenhardt (2007) and Yin (2009). A range of factors has been highlighted in selected projects, such as new businesses and innovative projects, and technology has been taken into account in several projects ranging from proven / old technologies to untested / open technologies. The capital expenditure related to these projects was between 20 and 600 million euros. Many geographic areas were assumed and project locations varied between industrialized sites. In keeping with the nature of this study, as well as previous studies on the NDP and open innovation, our main criteria for selecting firms were:

(1) Performing in an industry with a low-knowledge-intensive nature;

(2) Having a minimum of one NPD project in the past two years;

(3) Having a kind of external collaboration in NPD processes;

(4) Having a maximum of 250 staff; and

(5) Having an annual turnover of no more than 50 million euros.

In order to generate the highest variation among these cases, companies with different sizes, ages, and technological development levels were selected.

1.7- Outline

Chapter 1 is the introductory part of this thesis. It discussed the foreword and the background of the research, it defined the objectives and significance of the work, and it described the research methodology. Including the Introduction, this thesis is structured into five chapters.

Chapter 2 corresponds to the first objective of the research: "How complexity contribute in strategic decision for external collaboration in NPD process". In this chapter a comprehensive framework for project complexity indications has provided. This framework used in other parts of this study in order to include a relevant factor in strategic decision making. In this chapter also the measurement methods for different constructs of project complexity provided and also based on the results for this chapter we can find the most important complexity indicators which are considered by management in order to take their strategic decision. The dissemination strategy for chapter 2, which represents the first contribution of this thesis, is presented in table 1.

Table 1- Dissemination strategy for the first contribution: Chapter 2	
Reza Gheshmi, Hugo Zarco, Frederic Marimon (2018)	
Complexity as an Antecedent for External Collaboration in New Product Development Projects	
International Journal of Engineering and Technology (UEA), 7 (4.7) (2018) 97-105	
Methodology	Qualitative case study
Objective	Providing an integrated framework of project complexity and external collaboration in NPD projects.
Publication strategy	
Journal name	International Journal of Engineering & Technology
Area	General Engineering
Indexing	**Scopus**: Ranking: 2017 SJR (SCI mago Journal Rank) Score: 0.102 248/270, (7th percentile) 4Q **Other indexing:** , ProQuest (USA), Directory of Open Access Journals (DOAJ) Ulrich's Periodicals Directory (USA), Google Scholar, Research GATE (USA, EU)
Status	Published in 7 (4.7) 2018, 97-105

Chapter 3 assesses whether external collaboration in form of partnership can improve internal capabilities and reduce the level of project complexity. In this chapter we investigated that with which configurations of project complexity and absorptive capacity, the companies will tend to choose partnership as dominant mode for external collaboration in different phases of NPD projects. The contribution of this part of the thesis is to study different scenarios in which the companies will make external collaboration to improve their level of absorptive capacity and also reduce the level of project complexity. The dissemination strategy for chapter 3, which represents the first contribution of this thesis, is presented in table 2.

Table 2- Dissemination strategy for the first contribution: Chapter 3	
Reza Gheshmi, Hugo Zarco, Frederic Marimon (2019) **Supply Chain Management Strategies in Project and Absorptive Capacity to Implementation Partnership Strategy in New Product Development** **International Journal of Supply Chain Management, 8:2, 759-770**	
Methodology	Qualitative case study
Objective	Develop different configuration paths of project complexity and absorptive capacity, in different phases of NPD project, when the companies are willing to implement partnership as dominant mode of external collaboration.
Publication strategy	
Journal name	International Journal of Engineering & Technology
Area	Decision Sciences/Information Systems and Management
Indexing	**Scopus**: Ranking: 2017 SJR (SCImago Journal Rank) Score: 0.206 58/81, (29th percentile) Q3 **Other indexing:** DOAJ, EBSCO, Google Scholar, Scirus, GetCited, Scribd, Citeseerx, Newjour, SIS
Status	Published in Vol 8 (2)- April 2019

In Chapter 4 of this study, the importance of combining different knowledge sources in different phases of NPD projects has been studied. The contribution of this part is to implement the analysis in project phase level and find with which configurations of different sources of knowledge, the companies can make better performance. Also for checking the project performance, we have decomposed total performance to different dimensions of performance to see how the configurations are changing to obtain better result in each dimension of project performance. The dissemination strategy for chapter 4, which represents the first contribution of this thesis, is presented in table 3.

Table 3- Dissemination strategy for the first contribution: Chapter 4	
Reza Gheshmi, Hugo Zarco, Frederic Marimon (2019)	
Configurational path to NPD project performance- Involving source of innovation in project phases	
Journal of IIMB Management Review	
Methodology	Qualitative case study
Objective	Develop configurational paths to project performance, by involving different knowledge sources in NPD process.
Publication strategy	
Journal name	IIMB Management Review
Area	Management
Indexing	**Journal Metrics: CiteScore: 1.03, Source Normalized Impact per Paper (SNIP): 1.427, SCImago Journal Rank (SJR): 0.240** **Other indexing:** Directory of Open Access Journals (DOAJ), Web of Science, Scopus, Emerging Sources Citation Index (ESCI)
Status	Under review

Chapter 5 is the concluding chapter of the thesis. It concisely summarizes the findings of this work, provides some final thoughts on external collaboration in NPD projects, puts managerial implementation and suggests areas in need of further research.

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Chapter 2

Complexity as an Antecedent for External Collaboration in New Product Development Projects

Abstract

This study examines how project complexity in low technology-intensive small- and medium-sized enterprises (SMEs) contribute in implementation of open innovation practices, during their new product development projects. The main focus of this paper is to investigate the critical role of complexity in the project level to identifying the compatibility of those external sources involved in NPD. The low technology-intensive sector in Spain were chosen as a target context, there were many innovative SMEs operating in these industries and because these sectors were going through significant changes. Four external knowledge sources, Universities, suppliers, customers and competitors and four open innovation practices, Community, Platform, Partnership and seller-buyer agreement, in the new product development were identified. The study shows that in SMEs, project complexity plays an important role in selecting the external source and implementation of open innovation practices. The main conclusion of the study is that the external collaboration in new product development projects is determined by different dimensions of project complexities and in projects with different type of complexity, the SMEs follow different external knowledge sources and open innovation practices. The study results imply that SMEs benefit from opening up their innovation process in the new product development projects. The firms in this study employed a blend of strategies that is more compatible with dimensions of project complexity. They collaborated actively with different external knowledge source and different modes of collaboration, when they have determination of different dimensions of project complexity. Also, the study extends understanding of the strategic use of open innovation in SMEs by demonstrating how SMEs balance the risk of project complexity built on new product development and the benefit of creating a wider capability base with partnerships.

Keywords: *SME, New product development, Open innovation practices, Collaboration strategies, Collaboration modes.*

1. Introduction

New product development (NPD) refers to a focal point in competition that leads to many advantages, including higher product quality and a shorter time to market. Organizations are able to reach markets faster and more efficiently and might succeed in generating a sustainable competitive advantage that is not easy for their rivals to imitate. Therefore, NPD results not just in access to new markets but also in improvements to the competitiveness of companies and facilitates relationships with other firms (Veliyath et al., 2000). One of the main issues is the necessity to mobilize not only internal resources but also external actors in new product development. Thus, the process of development entails a series of actions that cut across many different functions, both external and internal, of an organization, and an increase in product performance and technological complexity will build relationships with important suppliers to contribute to the success of any organization. Regarding the advantages of integrating external innovation sources into the NPD process, many companies utilize a Japanesestyle policy for their suppliers. When they become responsible for designing the whole system as well as subassemblies, they are integrated systematically into the design and production process of the organization (Bell, 1999; Chesbrough et al., 2006; Karmarkar, 2004; Schulttze and Stabell, 2004; Tidd and Hull, 2003). Therefore, the innovative bonds among a lead manufacturer and the nearby group of external suppliers play a key role in generating flexibility, and they are assumed to be the main key to better products as well as a shorter development cycle (Ireland et al., 2002).

Collaborating not just with suppliers but generally with any external sources is accepted to increase organizational learning (Inkpen and Tsang, 2005; Powell et al., 1996), and, because new knowledge is usually retrieved from outside an organization, interorganizational relationships are critical (March, 1991). This is the same idea as that put forward in previous studies on open innovation, in which inbound open innovation was considered to be an important factor for innovation (Chesbrough, 2003). Open innovation has been described as the use of purposive outflows and inflows of knowledge to improve internal innovation and to expand the markets for using innovation externally (Chesbrough, 2003; Van de Vrande et al 2013). A great deal of attention has been paid to open innovation during the past years (Chesbrough et al., 2006; Elmquist et al 2009; West and Bogers, 2014; West et al 2014). Open innovation researchers have emphasized the need for focal firms to transcend their boundaries through external technology and knowledge sourcing. The current study discusses innovation complexity, environmental uncertainty and knowledge recombination as resulting in enhanced permeability of the boundaries in an organization and the need for them to interact more openly with external stakeholders and the environment (Karl-Heinz, 2015). The idea of open innovation includes a broad range of external factors, such as users, suppliers, customers, competitors and universities. The underlying mechanism to achieve external knowledge and generate open innovation in turn covers a broad range of alternatives, such as tournaments and contests, joint ventures and alliances, licensing, corporate venture capital, open source platforms and participation in different development communities.

Researchers have recently begun to consider the governance implications of open innovation (West Et al 2014). Generally, the results have demonstrated that improved relationships and knowledge flows from different external partners, particularly in uncertain contexts, produce better innovation consequences (Chesbrough, 2006; Lichtenthaler and Ernst, 2009). In addition to such an emphasis on the number or breadth of externalities, still other investigations have revealed the advantages of interacting with certain external constituents, for example including suppliers (Hakansson and Eriksson, 1993; Handfield and Lawson, 2007;

Petersen et al, 2003; Ragatz et al., 2002), customers (AtuaheneGima, 1995; Cooper and Kleinschmidt, 1987; Hippel, 1978), competitors (Hamel, 1991) and universities (Gerwin et al., 1992; Santoro, 2000) in the innovation process. Although the need to improve the access to external knowledge and to achieve greater openness in new product development projects is still compelling, the managerial and comparative governance implications of such a discussion are not clear yet. The mentioned study concentrates on aggregates on the form level, such as how specific aggregate quantities or types of external relations or governance forms could result in more innovation (Chesbrough, 2006; Lichtenthaler and Ernst, 2009). However, any kind of prescription or advice on the organizationallevel aggregates (which is for the entire organization to employ remarkably more open governance forms) could result in misspecified solutions for governance at the micro level. Most of the studies in fields of collaborative innovation and search strategies have emphasized the understanding of an —optimal‖ amount of external partners (Laursen and Salter, 2006, Bianchi et al 2013) and the critical role of various kinds of external sources (Laursen and Salter, 2006; Nieto and Santamaría, 2007). The most remarkable similarity between such investigations is that all of the analyses are on the organizational level, which shows that collaboration and searches are considered as decisions made for the organization as a whole and not decisions made according to the needs of certain NPD projects. The main goal of this paper is to focus on the critical role of complexity in the project level to identifying the compatibility of those external sources involved in NPD, like other research, and in determining whether the decision to include external sources is made on a project-by-project basis (Bahemia and Squire, 2010; Bonesso et al., 2011). To our knowledge, few studies have focused on the impacts of involving various forms of external sources as well as governance at the project level within the open innovation context (Tranekjer and Søndergaard, 2013). One of the exceptions revealed that adding external sources might have a negative impact on the project speed and cost (Faems et al., 2009; Leiponen and Helfat, 2010). However, little is understood about the particular mix of external sources and the reason for developing such external collaboration.

1.1 Complexity and External Collaboration

In this article we emphasize the inbound knowledge flow from external sources. Remarkably, studies in this field of search strategies and collaborative innovation have concentrated on understanding the governance mode and optimal knowledge source of open innovation in low-knowledge-intensity companies, with a focus on the theory of complexity, because structural innovation issues involve different kinds of complexity.

Complex issues are the same as complex systems, which consist of many different parts that interact in a non-simple way (Flood, 1990). Complex issues include a broad range of remarkably interdependent factors, knowledge and choices sets that should be recombined creatively to provide valuable solutions. Recently different studies have been performed to realize better project and knowledge management and to demonstrate the relationship between project management, especially innovation management, and complexity theory (Cooke Davies et al., 2007; Tepic, et al, 2013; Poutanen et al 2016). Many recent papers on external collaboration have clearly shown the important role of ―complexity‖ in current research on project management. Such investigations have offered valuable insights theoretically, and have sometimes linked practice and theory. However, it has been assumed to be a kind of black box; the exact elements that lead to complexity in NPD projects have not been described in detail. The necessity of a new paradigm for complex projects has been explained along with the importance of including soft system techniques for modelling a project to support its management (Bosch-Rekveldt et al., 2009). The management of NPD projects needs a framework regarding external collaboration. Such a framework can then be employed to adapt various further development phases of such projects to specific external collaborations to manage projects more effectively. However, currently no solid framework exists, based on both practice and theory, to support the identification and characterization of the external collaboration and to appreciate completely the external collaboration richness of various NPD projects.

1.2 Structure of the Paper

In Section 2 the literature survey is explained, and then the results of the case study are presented in Section 3. The achieved framework to incorporate project complexity and external collaboration into NPD projects is provided in Section 4 and discussed further in Section 5. Then Section 6 covers the foreseen application and development of the framework and the study limitations. The conclusions and recommendations for future studies are presented in Section 7.

2. Literature review

2.1 Project Complexity Definitions

To understand the project complexity elements that contribute to external collaboration, in the first step, complexity definitions were studied. According to the study by Geraldi (2009), the lack of an unambiguous and clear definition of project complexity or projects within a complex context has been reviewed in the literature. Even though project complexity and the surrounding environment definitely exert an impact on critical decisions in project management, such complexity is usually taken intuitively or based on past experiences. As mentioned by Parwani (2002), complexity means studying complex systems of which there is no united accepted definition due to their complexity. Regardless of the inherent difficulty in explaining complexity and various perspectives on complexity (Flood, 1990), a high-level project complexity definition should cover dynamic, structural and interaction factors (Whitty and Maylor, 2009), so complexity in projects can be assumed to be relevant to such dynamic, structural factors and their interaction, being broader than technological or technical domains. The goals and approaches concept (Turner and Cochrane, 1993) categorized projects based on whether the project goals are uncertain or well defined and whether the approaches to achieving such goals are uncertain or well defined. Then Baccarini (1996) presented a review of the project complexity concept within the construction industry in which he suggested that an objective measure of project complexity is relevant to many different interrelated parts, which should be operationalized based on interdependency and differentiation. In addition, he elaborated both technological and organizational complexities. Later Williams (1999) operationalized Turner's and Baccarini's concepts, to study the dimensions of project structural complexity, Williams defined measures of product complexity that influence project complexity. He noted that concurrent engineering leads to more reciprocal interdependency, adding to the complexity of the project. Besides the studies conducted by Turner and Baccarini, Williams considered that uncertainty adds to project complexity and thus can be assumed to be a project complexity dimension.

2.1.1 Softer Aspects and the Environment

Although the scholars mentioned above emphasized ―uncertainty and ―structural complexity‖, softer aspects and impacts from the environment are considered to affect the level of project complexity (Geraldi and Adlbrecht, 2007; Jaafari, 2003). Later Geraldi developed the concept described earlier by Williams and revealed the difference between the complexity of faith and the complexity of fact (Geraldi and Adlbrecht, 2007) as well as the complexity of interaction. Interaction complexity occurs at the interfaces between organizations and people and any other kind of business interaction (Geraldi and Adlbrecht, 2007; Poutanen et al 2016), which are assumed to be softer aspects that contribute to the total project complexity. Furthermore, explicit attention to softer aspects was identified in the study by de Bruijn et al. (1996). They considered that project complexity can be broken down into social, technical and organizational complexities. They considered that technical complexity is related to the technological uncertainty, uniqueness and dynamics of projects. Organizational complexity was considered to be relevant to the organization structure and the involved actors and project team, and finally social complexity concerns the involved actors, their interests and consequences and the risks of a project in relation to its environment. In addition, other studies have concluded that the environment is a key contributor to project complexity (Jaafari, 2003; Mason, 2007; Xia and Lee, 2005; KamSing Wong, 2014).

2.1.2 Gathering Elements from the Literature

Many literature sources, such as those noted in the previous section, have been utilized to define the elements that can contribute to project complexity. First, literature databases were searched for relevant papers with the keyword —project complexity (with a publication date of 1996 or later). These papers were reviewed along with the referenced papers. This process was stopped when no new and related referenced papers were identified. The elements contributing to project complexity were listed and then compared to define the key factors. Overall 28 elements contributing to project complexity were obtained from the literature search. To cover other factors, not included in the original ones, for example, uncertainty in methods and goals (Williams, 1999) which are respectively covered in —uncertainty of goals and —uncertainty of methods‖ and the level of interdependence among and between processes and products (Tatikonda and Rosenthal, 2000) was covered in —interrelations between technical processes and —dependencies between tasks‖. If the elements were too generic, for example uncertainty (Williams, 1999) or dependency on the environment (Vidal and Marle, 2008), they were not added explicitly to the final list; however, they were covered implicitly. Those elements that emphasize how to manage the complexity of a project rather than contributing to project complexity, such as project manager leadership style (Müller and Turner, 2007) or partners 'responsibility (Geraldi and Adlbrecht, 2007), were not included in the final list. Further, the elements were developed, defined and refined to enable a comparison with the elements identified in the case studies (Section 3).

2.2 Sources of Knowledge and Their Combination in NPD Projects

Although the reasons for including external sources to improve competitive advantages and innovative performance are global, they could be conceptualized in different ways (Sofka and Grimpe, 2010; Zhao et al 2015; Greco et al., 2015). For instance, Fey and Birkinshaw (2005) concluded that the innovation performance and R&D of an organization improve through the use of more relational governance, for example relationships with universities and alliance partners. In this regard Keilet al.

(2008) demonstrated that greater usage of different open governance modes, such as alliances, JVs and CVC investments, results in improved innovation consequences for organizations. The main intuition, considering formal governance arrangements or informal studies, is that having more external relations and greater search breadth could produce beneficial results for firms that are striving to innovate. In addition, Leiponen and Helfat (2010) showed that more sources of external knowledge result in more innovation as well as improved financial performance. Furthermore, Love et al. (2014) explained the same outcomes by demonstrating how the —breadth of external innovation linkages could result in better innovation outcomes. One method to conceptualize sources is to consider a number of sources or search breadth, as performed in the study by Laursen and Salter (2006), who identified a limitation to the benefits of adding external partners to the innovation objectives. The negative impact of too much openness might be because of the fact that the company experiences attention allocation issues while improving the number of its external partners (Knudsen and Mortensen, 2011) or higher marginal costs as a result of investigating different types of sources.

3. Research Question and Method

To develop a framework as noted earlier, in accordance with theory and practice, the main research question to be answered in the current paper is:

Which elements of NPD projects contribute to project complexity and how should these be included in a framework to characterize external collaboration in NPD projects?

The inductive research approach was selected to answer the research question (Sayer, 1992). This article attempts to synthesize the available empirical and theoretical studies in this field through a new empirical study. Its goal is not to test specific theories that will need a deductive method. Instead, it aims to establish a detailed explanation of external collaboration in new product development projects by utilizing an inductive strategy. First, a survey of the literature was conducted, through which variables that are considered to help different aspects of complexity in NPD projects were collected. Second, case studies were performed in which the factors contributing to project complexity and proposed open innovation practices (OIP) were identified in thirteen interviews from twenty-four projects in small and medium-sized firms that are active in various low-knowledge-intensive industries across Spain. Choosing multiple sources of data via fifteen cases allows triangulation and increases the construct validity of the research (Greene and McClintock, 1985). The interviewees were deliberately not made aware of the results of the literature analysis, and the case studies were then utilized to develop a more detailed framework to incorporate project complexity and external collaboration (specifically OIP) into NPD projects. The intention was to obtain a detailed framework because of its foreseen future application to tailored project management.

3.1 Data Collection

Spanish companies with low knowledge intensiveness and a minimum of one NPD project during the last two years in various industries constitute the sample population of this research. Both primary and secondary data sources were gathered, and the data construct validity was verified according to triangulation principles (Greene, 1990). A set of in-depth individual interviews was performed with firms (CEOs and R&D directors) following the procedure outlined by Eisenhardt (2007) and Yin (2009). Specifically, the interviews were designed to concentrate on NPD projects and any kind of external collaboration (with a focus on the open innovation framework) of the firm using semi-structured questions, and face-to-face interviews were performed by corresponding scholars (CEOs and R&D directors) at each company as well as follow-up telephone interviews. Each of these interviews took 60 to 100 minutes. All of the interviews were recorded and then transcribed, and, to ensure data validity, a database was generated. Overall, over 30 hours of recording and almost 250 transcript pages were gathered in 2016. After the interviews a copy of the case report and transcripts was sent to the interviewees to check them for any possible error to ascertain the authenticity and validity of the gathered data. Moreover, the collected data were triangulated with the information from many evidence sources from both observation and secondary information sources, for example online reports and information, company websites, tweets, material introduced by the informants (internal memos, company brochures and archival data) and news releases to improve the validity of the research (Greene, 1990).

3.2. Case Firm Selection

Following the suggestions provided by Eisenhart (1989), we used a multiple-case design with fifteen manufacturing firms within eight industries across Spain. In accordance with Yin (2002), replication logic was applied regarding case selection. Such an information-oriented approach was selected for —maximizing the information utility from small samples and single cases‖ (Patton, 2002). Together these cases covered less successful and successful projects regarding both meeting the budgets and delivering and scheduling estimates based on the expected results (project performance). A group of factors was considered in the selected projects, for example innovative projects and new business (market/business), and technology was included in different projects ranging from old/proven technologies to new/unproven technologies. In addition, the capital expenditure of such projects ranged from 20 to 600 million euros. Various geographical domains were considered, and the project location varied between remote and industrialized areas (location). The organizations were selected by employing purposeful/theoretical sampling according to Patton (2002) and Yin (2009).

Based on the nature of the current research as well as the NPD literature and open innovation, our main criteria for choosing these firms were: (1) operating in a low-knowledge-intensive industry, (2) having at least 1 NPD project during the last 2 years, (3) having any form of external collaboration in the NPD process, (4) having no more than 250 employees and (5) having an annual turnover not exceeding EUR50 million. In addition, to create the greatest variation among such cases, firms with different ages, sizes and levels of technological development were selected. More than 60 invitation letters were sent to senior managers, and interviews were performed successfully with 15 firms.

3.3 Data analysis and Interpretation

The selected unit of analysis was a completed new product development project, in which —project took a broad definition, for example including all of the activities from beginning to close-out (project proposal/initiation, project design/development, project execution/implementation and project commercialization/closeout were excluded).

Following a protocol, 30 semi-structured interviews overall were performed with general managers or their representatives and R&D directors of a total of 24 projects. During these interviews we asked the candidates open questions about the variables that had contributed to the complexity of a specific

NPD project from their perspective. To initiate the interview and contribute further analysis, their definition or interpretation of project complexity was elicited. The candidates did not know the literature results. All of the transcripts were analysed to understand the elements contributing to project complexity. A matrix was developed with the elements contributing to the project complexity of each NPD project in the rows and the total of 30 interviews in the columns (for each NPD project). Moreover, the respondents were asked about any kind of external collaboration (governance mode and knowledge source) that they had engaged in during each project to understand the proper mode of external collaboration to handle project complexity.

For the data analysis, we considered this new phenomenon from various perspectives and angles. We identified project complexity causes from various perspectives, for example a lack of capabilities and resources, fast commercialization practices and business model selection. Moreover, we identified the relationship between large and small companies in the NPD process. We used both inductive and deductive methods in this analysis to interpret the cases better and to realize the meaning of theoretical constructs (Eisenhardt, 1989). We used both cross-case and within-case analysis. The within-case analysis includes a description of each case in its own context. This is a critical aspect of studying each case to gain an effective understanding and perspective (Eisenhardt, 1989).

3.4 Case Study Results

From the case findings, the variables contributing to project complexity from a practice point of view were collected, complementing or confirming the literature elements. Almost all of the identified elements in the literature survey were confirmed independently by the interviewees without asking explicit questions.

Many aspects contributing to project complexity were identified in these fifteen cases, demonstrating strong support for these aspects specifically. In an effort to summarize them, they were categorized based on the —what, —who and —how of the projects as follows:

The —what of a project regarding the content (the types of complexity in each NPD project);

The —who of a project regarding the involved and collaborating parties (the number of stakeholders and the different perspectives of stakeholders);

The —how of a project regarding open innovation practices and governance mode practices (the number of tools and practices).

In analyzing these aspects of —what, —who and —how in the framework, logically —what elements were assigned to technical, organizational, environmental and interaction project complexity dimensions. The —who‖ elements, which are relevant to the involved knowledge sources, were assigned to various NPD projects. The —how‖ elements were assigned to different practices of open innovation and governance mode that are implemented in NPD projects and that are obtained by a partnership, seller/buyer contract, innovation community and platform or innovation mall (Bellantuono et al., 2013; Faems et al., 2005; Felin and Zenger, 2014; Love and Roper, 1999; Tether and Tajar, 2008). Those elements that describe the —what, —who and —how of a project can be considered as key factors that define project complexity dynamics.

Besides the elements listed in Table 1, the practitioners explained some elements that do not contribute to project complexity but instead make it harder to manage a project, such as poor motivation, poor communication and poor relationship management as well as unclarified responsibility distribution. These are known as project management flows that do not contribute to a project‘s intrinsic complexity because they are manageable; thus, they are not included.

Table 4- Elements contributing to project complexity from the literature and case study sources

Technical	Organizational	Environmental	Interactional
• Product novelty	• Goal variety	• Market variability	• Previous experience
• Production site differentiation	• Goal alignment	• Local regulations	• Formality
• Technological base	• Goal clarity	• Previous knowledge in the market	• IP protection
• R&D expenditure	• Goal uncertainty	• Market stability	• Information flow
• R&D time	• Task formalization	• Market competitiveness	• Partner's previous experience
• Financial budget	• Task diversification		• Stakeholders' dependency
• Internal capabilities	• Task variability		
• Variability in product components	• Task dependency		
	• Task uncertainty		

3.5 Proposed Structure for the Framework

Studying previous investigations and gathering elements from them (Table 4) revealed that it is not just the technological or technical dimensions that define the complexity of a project; environmental and organizational aspects also have a key role. De Bruijn (2003) identified three complexity dimensions: organizational complexity, social complexity and technical complexity. Then they developed a framework including the environmental, organizational and technical elements contributing to project complexity, suggesting the inclusion of various dimensions of project complexity in NPD projects. Baccarini (1996) introduced two forms of complexity in project systems: technological and organizational complexity. Williams (1999) expanded Baccarini's conceptualization of project complexity and then attributed both technological and organizational complexity to structural complexity and assumed uncertainty as the other dimension. Later different scholars designed many different frameworks to realize, classify and evaluate project complexity better from various perspectives. For instance, Geraldi and Adlbrecht (2007) categorized complexity into three types: faith complexity (the complexity in creating something novel, solving new issues or handling high levels of uncertainty), fact complexity (complexity in handling a large amount of independent information) and interaction complexity (complexity relevant to interfaces among locations, for example ambiguity, politics and multiculturalism).

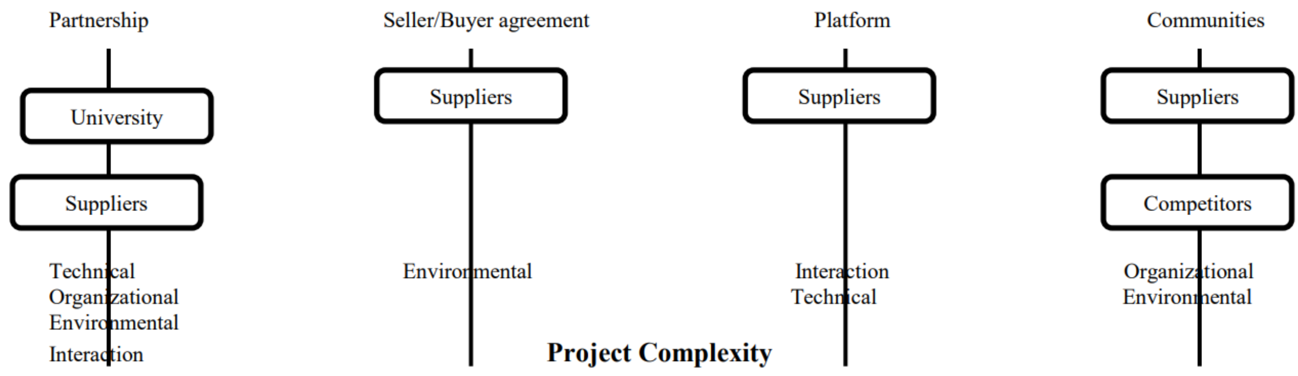
Bosch-Rekveldt et al. (1996) suggested the technical, organizational and environmental (TOE) framework to evaluate engineering projects‘complexity. By means of the TOE framework, engineering projects‘complexity could be measured by technological complexity (goals, tasks, scope, risk and experience), organizational complexity (size, risk, trust, resource and project team) and environmental complexity (risk, market conditions, location and stakeholders). He et al. (2013) employed a six-category framework for project complexity, consisting of organizational, technological, environmental, goal, information and cultural complexities, to evaluate the complexity of mega-projects. Considering the main goals of this study, to assign the contributing factors to NPD project complexity, we adopted the TOE model, incorporating with some changes resulting from mixing this model with the model proposed by Geraldi and Adlbrecht (2007), to separate interaction complexity and classify all of the relevant variables in this group. The traditional technical perspective is highly concentrated on the project content (T), the organizational view (O) covers softer dimensions, the environmental view (E) includes impacts from the environment and interaction (I) concerns any type of external collaboration proposed during the NPD projects. Therefore, to develop a framework of project complexity, all of the variables were assigned to the technical, the organizational, the environmental or the interaction category (TOEI) (Table 4).

4. The TOEI Framework for External Collaboration in New Product Development Projects

To design a framework for external collaboration in NPD projects from a complexity perspective, the elements obtained from the literature and those from the cases were combined and then recorded. To achieve richness in the framework, however, and to prevent the inclusion of —arbitrary‖ factors, the following criteria for including elements in the framework were presented. The final TOEI framework is demonstrated in table 1 and includes eight T elements, nine O elements, five E elements and six I elements. All of the proposed elements in the T, O, E and I categories have both literature and empirical evidence, providing support for the elements from both practical and theoretical points of view. In the E category, there are three elements with partial empirical evidence (supported by some cases), three of which are relevant to the project location and one of which is relevant to the market condition. The obvious absence of such aspects in other cases might be due to the industry under consideration or due to this research being approached with a deliberate choice from project management insights. This explanation might also apply to those elements with empirically supportive evidence in the O category, such as HSSE awareness and size (number of locations), and the former is significantly related to the process industry (food and beverage production). We might not find a —quality requirements‖ element (T category) in previous studies, since little attention has been paid to quality management in the literature (Turner, 2010). To design the TOEI framework, we kept the richness of the elements contributing to project complexity and external collaboration as identified in previous studies and practices and did not decrease them to a 2×2 matrix, as performed in a recent study by Whitty and Maylor (2009) on a matrix of structural dynamic interaction.

The broad TOEI framework, which has three levels consisting of complexity categories, appropriate external collaborators and OIP, suggests an opportunity to argue on different aggregation levels that various aspects of parties and stakeholders who are involved in a project can be a function of the level of project complexity. Moreover, the current set-up allows framework extension for use in all industries. Therefore, this developed framework could be utilized to evaluate engineering project complexity and to propose some possible external collaboration solutions (source and mode). Evaluating the complexity of a project by its nature is a subjective process in Which perceived complexity according to past experiences has a key role. Due to differences in experiences and skills, people who use the framework and evaluate a specific project or phase might reach various conclusions about complexity. Here the main goal of the framework is to obtain better knowledge of projects ‘complexity and external collaboration. Excluding the absolute scores for various elements, this framework helps to identify the areas of complexity in a particular project. Understanding such areas of complexity, attention will be paid to their management, and, as noted by Geraldi (2009), assessing the complexity itself is a tool to reinforce active management.

Figure 2- TOEI Framework



5. Discussion

Traditionally, size, novelty and innovativeness have been considered as dominant yet criticized project complexity measures (Williams, 2002). In this paper a few participants pointed out traditional measures as contributing to project complexity. Often aspects that are related to innovativeness and/or novelty, such as the ―number of new technological tools and methods‖ and the ―number of stakeholders‖, were noted; thus, it is important to refine ―innovativeness‖, a general aspect, as a contributor to project complexity and results in implementing the external collaboration. This will support the overall idea of the current study, which is to design a detailed framework to incorporate external collaboration and complexity into NPD projects.

• The TOEI framework includes many elements related to uncertainty and structural complexity. Organizational complexity and technical complexity are both included explicitly as key classifications of project complexity. Most of the elements in the framework ‘s organizational category has a structural character, such as the scope, number of goals and tasks, dependencies between different tasks and so on. In addition, uncertainty of methods and uncertainty of goals are covered in the organizational category elements. The dominant open innovation modes that were obtained from the participants to reduce these types of complexities in the projects are partnerships and some other modes, like communities, which are open innovation modes that can be applied in NPD projects to eliminate some or all of the uncertainty and the project complexity. Appropriate collaborators in this type of complexity are suppliers and in a few cases customers. This shows that suppliers can play an important role in reducing the complexities. Many structural elements are identified in the technical category, for example the Product novelty, Production site differentiation, Technological base, R&D expenditure and internal capabilities. In addition, the proper and common external collaborators in this part are suppliers and universities and the dominant OI mode partnership. Here it can be observed that most of the appropriate and common knowledge sources solving the environmental complexity are suppliers and competitors, and the dominant governance modes that are helpful in managing such environmental complexity are partnerships and seller/buyer agreements. In the case of interaction complexity, Suppliers and universities play a role, and the OI mode is partnerships and platforms. In the TOEI framework, the environment and softer aspects are included explicitly. Softer aspects can be identified in both the environmental and the organizational category in the elements of the TOEI framework, for example the Market variability, Local regulations, Previous knowledge in the market, Market stability and Market competitiveness. Besides, the environmental category covers elements such as the competition level, political influences, required local content and strategic pressure. Here it can be observed that most of the suitable and common knowledge sources addressing the environmental complexity are suppliers and competitors, and the dominant governance modes that are helpful in managing such environmental complexity are partnerships and seller/buyer agreements and in some cases communities. In the case of interaction complexity, suppliers play a role and the OI mode to manage some aspects of this complexity, such as IP protection and/or information flows, is partnerships.

In the TOEI framework, risk is assumed to be a contributor to project complexity. To assert the critical role of risk as a contributor to a project ‘s complexity, the TOEI framework contains a specific risk element in all of the four categories and high risk from the technical, organizational, environmental or interaction perspectives. In addition, the risk aspects are all covered in other different elements of these four categories, particularly topics regarding uncertainty, political influence and the IP protection condition. Here it is clear that the most appropriate and common knowledge sources are suppliers, clients and competitors, and the governance modes of partnerships, seller/buyer agreements and in some cases platforms could be applicable to manage such external collaborations.

To sum up, it can be said that the developed TOEI framework fits the existing critical literature concepts defined in the previous section. In addition, this framework presents an —integrative‖ list of elements contributing to external collaboration and project complexity in NPD projects. It can integrate various theoretical concepts and practice perspectives.

6. Managerial Implementation and Development of the TOEI Framework

The TOEI framework could be employed as a basis on which to measure NPD projects 'complexity. Using the TOEI framework for projects provides a good idea of where we should expect the complexity to arise during the project and what the appropriate knowledge sources and governance forms are to handle such complexity. Utilizing the TOEI framework can for example support risk assessment during the early phases of a project. Due to complexity changes within the life cycle of a project, using the framework in different stages of projects needs to be considered to grasp the external collaboration application. Utilizing the complexity evaluation might clarify remarkable problems in a project (Geraldi, 2009). This framework can support the complexity assessment. The main goal of employing the framework is to adapt the frontend development phases of a project better to certain complexities by means of a complexity footprint. In the early stages, a project can be measured regarding the expected complexity, and particular actions can be taken to manage external collaboration. For instance, in a project in which we can expect predominantly technical complexities, we might need different governance modes or knowledge sources from a project in which we expect predominantly environmental complexities. Identifying, understanding and characterizing such complexities via the use of the TOEI framework in the early steps of a project and the next phases are considered to improve project management.

According to the footprint, it might be decided to put more or less effort into open innovation management, process management, risk management and so on in line with the suggested approaches, for example the study by Jaafari (2003) on risk management or the study by Aaltonen et al. (2008) about the management of external partners. According to the ideas of the current literature, external partners can be chosen and/or developed later according to the required competencies to manage specific complexities (Felin and Zenger, 2014).

More TOEI framework developments are predicted to overcome the limitations of the study. The first limitation is the qualitative nature of the study. To design the TOEI framework, the empirical findings revealed data saturation for the analysed cases. To reinforce the existing results, a survey across the industry was conducted with a more quantitative nature. This could not only be considered as a strength of this framework but could also represent a limitation of the study. Thus, we are not able to claim that the TOEI framework is complete.

7. Conclusion

To help to manage project complexity and external collaboration, this article provided a framework for defining the external collaboration in NPD projects. This framework is based on both empirical data and literature. Using this framework for a certain project provides an understanding of its complexity, indicating potential methods to manage new product development projects more efficiently. The TOEI framework can be utilized to evaluate a project 's complexity and to predefine possible support from external parties. Due to the external collaboration dynamics, we can predict repeated use in different phases of a project.

Applying an inductive method through combining the literature points of view with the elements obtained from30 interviews regarding 15 cases, the TOEI framework provides a broad understanding of external collaboration. Overall 28 elements were identified, contributing to external collaboration and project complexity in the following 4 areas: technical complexity, organizational complexity, environmental complexity and interaction complexity. The number of elements in the framework was not decreased deliberately to explain the richness of project complexity. In the TOEI framework, 4 different levels were identified to facilitate its use: 4 categories known as TOEI, 4 different knowledge sources and 4 modes of external collaboration. It will provide a chance to argue which aspects will make a particular project complex on different levels with different stakeholders and parties involved in the project. This set-up is flexible and allows framework extension, for instance for use in a specific industry.

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Chapter 3

Supply Chain Management Strategies in Project and Absorptive Capacity to Implementation Partnership Strategy in New Product Development

Abstract

To develop new and successful products, supply chain management can be efficient way as a multidisciplinary process. It appears logical to consider that some elements, such as fast changes in technology, a flexible process of production, and international rivalry, have a direct relationship across various knowledge sources and are more necessary for introducing timely and profitable new products. Our main emphasis is to make a comparative assessment for the role of decomposed attributes of complexity level in new project development (NPD) and internal abilities to choose partnership as dominant mode for external collaboration in different phases of NPD, by using supply chain management design and fsQCA method across 125 NPD projects in low technology intensive SMEs in Spain. The results provide support for the role of absorptive capacity and different dimensions of project complexity in developing a codevelopment strategy (Partnership) in different phases of NPD projects.

Keywords—Open innovation, supply cahin management, absorptive capacity, project complexity, co-development, fsQCA, new project development

1. Introduction

Practitioners and academics agree that innovation is one of the necessary factors to thrive in a global dynamic economy. New product development (NPD) and innovation provide only a certain level of adaptation to the fast and disruptive modifications in economic, technological, social, and regulatory contexts of organisations; however, they provide a tool to drive and form such changes as well as other benefits, including higher-quality products and decreased time to market. Hence, they not only offer a critical competitive advantage and key factor of growth and wealth of organisations (Camison & Villar-López, 2011; Drucker, 1985) but also help to improve facilities and the flexibility of relationships with other companies (Veliyath et al., 2000). To develop new and successful products is a multidisciplinary process. It appears logical to consider that some elements, such as fast changes in technology, a flexible process of production, and international rivalry, have a direct impact across various companies and are more necessary for introducing timely and profitable new products. In addition, companies have coordination mechanisms, such as quality functional deployment procedures; organisational structures, such as cross-functional teams, and capabilities, such as absorptive capacity, in order to improve their functional interaction level and knowledge integration during NPD (Birkinshaw, Hamel, & Mol, 2008; Damanpour & Aravind, 2011; Hamel, 2007; Vanhaverbeke & Cloodt, 2014).

Many studies seem to show positive impacts of knowledge source integration in NPD and innovation success in many cultural environments (Battisti & Stoneman, 2010; Damanpour, Walker, & Avellaneda, 2009; Ettlie 1997; Evangelista & Vezzani, 2010; Ganter & Hecker, 2013; Laursen & Salter, 2006; Mol & Birkinshaw, 2009; Nieto & Santamaría, 2007; Tether & Tajar, 2008; Vaccaro, Jansen, Van Den Bosch, & Volberda, 2012). Therefore, we can conclude that organisations experience new methods that include more external factors and support exchange of information and collaboration in different contexts. Moreover, participating in open innovation involves ambiguity and uncertainty (Chesbrough, 2003, 2006; Laursen & Salter, 2006; von Hippel, 2005; von Hippel & von Krogh, 2003; von Krogh et al., 2003; for an overview, see Dahlander & Gann, 2010; Van de Vrande, de Jong, Vanhaverbeke, & de Rochemont, 2009; West & Bogers, 2013). The level and type of knowledge sharing and information exchange are different in open innovation stages and procedures, because innovation issues are varied due to the complexity level (Ancona & Caldwell, 1992; Madhavan & Grover, 1998). Complex issues include a variety of interdependent factors, knowledge, and choices that should be addressed creatively in order to generate useful solutions (Felin & Zenger, 2014, Murad et al., 2016; Zenger et al., 2011). This complicates conditions for senior managers while attempting to answer some questions: How can we control the ambiguity and uncertainty of open innovation while finding solutions for problems regarding strategic innovation? What are the important antecedents to select a specific governance mode for open innovation in various NPD projects stages?

Our main emphasis is in comparative assessment of the role of decomposed attributes of complexity level in NPD project and internal abilities to choose partnership as a dominant mode for external collaboration at various phases of NPD. We assumed the project to be the unit of analysis, since aggregated analysis at the organisation level may cause issues (Griffin, 1993; Gupta et al., 1986; Souder & Song, 1998). The following section reviews past studies regarding partnership in NPD and also points to many inconsistencies and gaps in their findings. Then, section 3 will present the configuration theory and fsQCA about investigations on open innovation practices in the NPD process. Section 4 explains the specification of the concrete model and data. In section 5, we provide a summary of the results. Finally, section 6 discusses potential opportunities for future studies.

2. NPD project complexity, absorptive capacity, and partnership

As noted earlier, open innovation implementation in NPD projects is a highly discussed problem in technology and innovation management studies. However, many topics in this subject remain largely unexplored and need more empirical and theoretical study. There are two gaps to be recognised, which are related to aim of this study: (i) there is little investigation into how varied project complexity dimensions are and to what level organisations' internal capabilities impact the choice of the mode of open innovation, and (ii) there are few contributions that consider choosing partnership as the main open innovation mode in various phases of NPD projects.

Partnership and absorptive capacity are concepts initiated from case studies in large R&D organisations, such as Xerox (Chesbrough, 2003a, 2003b). According to Spithoven et al. (2013), it is helpful to investigate such concepts in a particular context, such as SMEs or a traditional sector context. The traditional industries that are known generally by the presence of SMEs show little R&D intensity (European Communities, 2006) or innovation capacity (Acha & von Tunzelmann, 2005), so their absorptive capacity usually is operationalised as the intensity or existence of R&D facilities of a company (Lane & Lubatkin, 1998; Lin, 2003; Leahy & Neary, 2007; Oltra & Flor, 2003; Thérin, 2007; Veugelers, 1997; Zahra & Hayton, 2008). Zahra and George (2002) studied the literature regarding absorptive capacity and defined it as a series of organisational processes and routines through which companies acquire, transform, assimilate, and exploit knowledge in order to provide dynamic capability in the organisation. These four aspects allow the company to reconfigure its resource base and adapt to changing conditions in the market to obtain a good competitive advantage. Thus, such companies will ask third parties to assist them to provide absorptive capacity by scanning the market for new technologies, providing the ability to absorb the acquired technology and conduct complementary R&D activities, if required. More integration and responsive and effective partnership will be achieved while reducing transaction costs and allowing more flexibility in managing internal abilities (Dyer, 1997; Ettlie & Pavlou, 2006; Teece, Pisano, & Shuen, 1997).

Partnership and NPD project complexity – It has been suggested that issues in NPD phases can be different in four specific project complexity dimensions, and such dimensions need alternative methods to search for solutions (Felin & Zenger, 2009, 2014; Kim & Wilemon, 2003). To solve complicated issues, a company needs to have a level of knowledge or theory of interaction patterns between relevant knowledge and choices (Felin & Zenger, 2009). On the other hand, simple issues are those in which solutions' value is not formed by interactions between choices and the related sets of knowledge (Leiblein & Macher, 2009; Macher, 2006). They provide many choices for independent design by having more separate and specific knowledge in order to create solutions with high value. Complex issues might be different in terms of their complexity aspects (organizational, technical, inter-organisational, and environmental) in various projects and their phases (Gheshmi et al., 2018; Kim & Wilemon, 2003). The governance mode we choose in external collaboration will be different with the change in the level of project complexity. (Bagherzadeh & Brunswicker, 2017: Felin & Zenger, 2014; Gheshmi et al., 2018).

Forms of governance are different in terms of their ability to support a variety of knowledge exchange regarding theory building. In addition, they are different in their capability to motivate self-revelation to solve various kinds of complexities in NPD stages.

The current study investigates a new generation of NPD practices known as co-development alliances. Specifically, the goal is to initiate a process theory for partner selection in order to reach favourable antecedents to implement co-development alliances. Co-development alliances are non-equity collaborative relationships between two or more companies to generate value by transforming and integrating pools of know-how relevant to new service or product development (Link & Bauer, 1989). Alliances, partnerships, and corporate venture capital (CVC) involve a set of governance types that help solve issues of high or intermediate complexity (Felin & Zenger, 2014). Different governance mode is distinct at some point, they share much regarding their support to search for knowledge and solution and also their strategy to communication channels, incentives, and property rights. In addition, such a category not only supports the transfer of knowledge but also optimum means of communication that enable knowledge integration and theory formation. Like an authority-based hierarchy, CVC and alliances consider the focal company or the external partner in order to identify external knowledge relevant to the identified issue (Bagherzadeh & Brunswicker, 2017; Cassiman & Veugelers, 2006; Felin & Zenger, 2014).

We emphasise that investigating the method of including the external sources at the project level, particularly various stages of NPD, is crucial, since each NPD project may require different levels and types of input from different external sources; thus, it might benefit from generating some types of external collaboration that are more helpful to transfer knowledge and solve problems and complexities. The forms of collaboration and sources of knowledge are some decisions which are made in each project separately (Bahemia & Squire, 2010; Bonesso et al., 2011). Previous studies have focused on different types of sources and combinations at the project level (Tranekjer & Søndergaard, 2013). There is limited literature on empirical open innovation studying the involvement and combination of external sources at the project level. This problem was identified by Bahemia and Squire (2010), who proposed a conceptual framework that includes three dimensions of inbound openness: ambidexterity, depth, and breadth.

3. Configuration theory and analysis

3.1 Configuration theory

Configuration theory is a method to identify how the organisational structure of a company is related to strategic intent (Hult, Ketchen, Cavusgil, & Calantone, 2006). The theory is rooted in previous studies (Miller, 1996) and suggests that for each individual context, certain organisational configurations of strategy and structure will fit better compared to others and result in better performance (Dess et al., 1993; Meyer et al., 1993). The stronger the fit between structure and strategy is, the better the performance (Vorhies & Morgan, 2003). Meyer et al. (1993) explain organisational configurations as any kind of multidimensional constellation of conceptually distinct characteristics which take place together. Instead of looking for global relationships that are similar in all organisations, this theory suggests that relationships could be identified better regarding sets of conditions (Vorhies & Morgan, 2003). In addition, a proper set of variables or conditions will not usually result in better performance (Doty et al., 1993). The main focus of configuration theory is the fact that structure and strategy elements usually generate few manageable amounts of configurations, Gestalten, and archetypes, which represent a large number of high-performance companies (Miller, 1986, 1996). Therefore, there are many methods for success. Meyer et al. (1993) noted:

If organizations were complex amalgams of multiple attributes that could vary independently and continuously, the set of possible combinations would be infinite. But for theorists taking the configurational perspective, this potential variety is limited by the attributes' tendency to fall into coherent patterns. This patterning occurs because attributes are in fact interdependent and often can change only discretely or intermittently.

According to the fact that amount of ideal configurations is not high and since such ideal configurations are made of ‘tight constellations of supportive mutual factors’ (Miller, 1986) and also are almost in nature long lasting (Miller, 1986, 1996), using the configurational perspective will help to analyze and describe complex interactions between constructs of various domains with no simplification of fact in this study. In the current research, the configurational lens is focused on the structure of the relationship (e.g. multidimensional constellation of features in a relationship) and on selecting a collaboration or co-development strategy.

3.2- Operationalizing configuration theory SCM through fsQCA

Set-based methods like Fuzzy Set Qualitative Comparative Analysis (fsQCA) involve proper tools to provide nonlinear relationships and complementarities between constructs (Greckhamer, Misangyi, Elms, & Lacey, 2008; Ragin, 2000; Woodside, 2010, 2013). Rather than disaggregating different cases into several independent factors, such an analysis can conceptualize the variables as combinations of various attributes manifested by a set membership. fsQCA provides knowledge of how different causes will combine in order to generate a specific outcome that creates high casual complexity levels and defines efficient and important conditions regarding configurational outcomes.

fsCQA is useful to conduct configurational analysis for external modes of collaboration. The configurational analysis takes a pragmatic approach in order to organise interdependent cause–effect relationships into suitable accounts, showing variance in the innovation behaviour of organisations (Doty & Glick, 1994; Fiss, 2009, 2011; Short, Payne, & Ketchen, 2008). This analysis joins parsimony and complexity together through integration of many causal relationships into a few typified profiles (Fiss, 2011). Moreover, fsQCA facilitates to make difference between sufficient and necessary causal condition to implement co-development as the dominant mode for external collaborations (Fiss, 2011). If the important conditions are those attributes demonstrated by each focal-set member in organisations, sufficient conditions will define other combinations of the attributes, leading to the outcome of interest.

With some exceptions (e.g. Cheng, Chang, Li, & Woodside, 2012; Cheng, Chang, & Li, 2013; Froesen, Luoma, Jaakkola, Tikkanen, & Aspara, 2016; Ganter & Hecker, 2014; Ordanini, Parasuraman, & Rubera, 2014; Schneider, Schulze-Bentrop, & Paunescu, 2010; Tóth, Thiesbrummel, Henneberg, & Naudé, 2015), fsQCA has not been applied in studies on innovation management. Such a lack of attention is surprising, since causal interrelationships' complex patterns among success, innovation activity, and contributing factors as well as equifinality and causal asymmetry are related to a wide range of subjects in innovation study.

4. Research and method design

4.1-Data sources

Spanish firms with little knowledge intensive and at least one NPD project during the last two years in different industries are considered as our sample population for this research. The primary and secondary data sources were collected and the construct validity of data verified based on triangulation rules (Greene, 1990). A series of in-depth interviews with firms were conducted individually (R&D directors and CEOs), in line with the process outlined by Eisenhardt (2007) and Yin (2009). The interviews were developed to focus on NPD projects and any type of external collaboration (with an emphasis on open innovation frameworks), as well as absorptive analysis of the company by means of face-to-face interviews and semi-structured questions. The interviews were conducted by corresponding people (R&D directors and CEOs) at each firm along with telephone interviews for follow-up. Each interview lasted 60 to 100 minutes. All of them were recorded and transcribed, and to ensure data validity, a database was established. In total, more than 30 hours of recording and 250 transcript pages were collected in the years 2017 and 2018. After each interview, a copy of the transcript and case report was sent to the participants in order to control for errors and ensure that the collected data were valid.

T-test analyses demonstrated that both groups had no significant differences in their answers, which means there was no systematic difference between early and late respondents. Most of the interviewees were male (66%) and aged between 36 and 40 years old (33%) and 31 and 35 years old (26%). In terms of their educational level, 5% had a PhD, 33% a master's degree, 45% a bachelor's degree, 17% a college degree, and almost 0.4% a vocational school diploma. The gathered data were triangulated with collected information from several secondary and observational sources, including company websites, online information and reports, tweets, websites, materials introduced by informants (company brochure, internal memo, or archival data), and news, in order to validate the study (Greene, 1990). Moreover, to collect more information on certain factors (absorptive capacity), we distributed questionnaires to the same people.

4.2 Case firm selection

Related to the suggestions of Eisenhardt (1989), we employed a multiple case design, which included 125 NPD projects from 85 manufacturing companies across eight industries in Spain. Following Yin (2009), replication logic was used for case selection. This information-oriented method was chosen to improve information utility from single cases and small samples (Patton, 2002).

A set of factors was emphasized in the chosen projects, such as new business and innovative projects, and technology was considered in various projects ranging from proven/old technologies to unproven/open technologies. Capital expenditure for these projects ranged from 20 to 600 million euros. Many geographical domains were assumed, and the project locations varied between industrialized and remote locations. The firms were chosen using theoretical/purposeful sampling based on Patton (2002) and Yin (2009).

According to the nature of the present study as well as previous NPD studies and open innovation, our primary criteria to choose the companies were:

1- Performing in an industry with a low-knowledge-intensive nature;
2- Having a minimum of one NPD project in the past two years;
3- Having a kind of external collaboration in NPD processes;
4- Having a maximum of 250 staff; and
5- Having an annual turnover of no more than 50 million euros.

In order to generate the highest variation among these cases, companies with different sizes, ages, and technological development levels were selected.

4.3 Data collection

The considered unit of analysis is a NPD project with a narrow definition, for example, having all activities from start to close out (proposal, initiation, design, development and execution, implementation, and commercialization of project).

Based on a protocol, 85 semi-structured interviews were conducted with the general managers or representatives and R&D directors from 125 projects. In these interviews, we asked open questions regarding various external collaboration modes as well as knowledge sources that they engaged in each project in order to identify the most appropriate mode and knowledge source for external collaboration in stages of NPD projects. Additionally, the participants were questioned about the absorptive capacity of the company and its values.

We employed both deductive and inductive approaches in this study to define the cases properly and to understand the meaning of theoretical aspects (Eisenhardt, 1989). We also applied both within-case and cross-case analysis. Here, within-case analysis covers the description for each specific case in its own context. This is an important dimension of analysing each case to achieve helpful knowledge and insight (Eisenhardt, 1989).

4.4 Measurement

The main goal of this research is to investigate potentially related antecedents of establishing co-development as the dominant mode of open innovation in an NPD process. Particularly, this research initiates and empirically tests a conceptual model regarding organized antecedents of open innovation practices and external collaboration according to changing causal recipes.

After defining potentially related product innovation antecedents according to previous studies and our key goal, we created sample items using expert interviews and a focus group. The members of the focus group included four experts in open innovation studies and R&D management and four senior managers working in R&D departments in SMEs. Table 5 presents potential constructs and measurement techniques.

Table 5- Potential constructs for developing co-development in the NPD process

Variable	Type	Measurement method	Description
Co-development [5].	Binary	= 1 if the company applied codevelopment in the NPD Project ,= 0 otherwise	Any type of none equity partnership
Technical complexity	Ordinal	Measured on a five-point Likert type scale	1 = not agree at all, 5= fully agree
Organisational complexity	Ordinal	Measured on a five-point Likert type scale	1 = not agree at all, 5= fully agree
Environmental complexity	Ordinal	Measured on a five-point Likert type scale	1 = not agree at all, 5= fully agree
Intra-organisational complexity	Ordinal	Measured on a five-point Likert type scale	1 = not agree at all, 5= fully agree
Exploration absorptive capacity	Ordinal	Measured on a five-point Likert type scale	1 = not agree at all, 5= fully agree
Transformation absorptive capacity	Ordinal	Measured on a five-point Likert type scale	1 = not agree at all, 5= fully agree
Assimilation absorptive capacity	Ordinal	Measured on a five-point Likert type scale	1 = not agree at all, 5= fully agree
Exploitation absorptive capacity	Ordinal	Measured on a five-point Likert type scale	1 = not agree at all, 5= fully agree

According to guidelines suggested by Hair, Ringle, and Sarstedt (2011), analysis of exploratory factors was performed on the variables of the study. The model's convergent validity was tested by means of significance of indicators and factor loadings. All insignificant items or items with less than 0.5 loadings were omitted from the measurement model. The guidelines provided by Chin (2010) were followed to ensure that the variables reached the needed criteria for the discriminant validity, which needs the factor loading for each indicator on its relevant variable to be more than its loading on other variables. Table 2 presents findings of the factor loadings of the remaining items as well as variable reliability examinations. The Cronbach's alpha value should be more than 0.6 (Nunnally & Bernstein, 1994), and the composite reliability should be more than 0.7 (Hair et al., 2011) for all the variables in this study. According to the results presented in Table 6, the reliability and dimensionality of all variables were acceptable.

Table 6- Reliability test of the variables

	Factor loading	**Composite reliability**	**Cronbach's alpha**
Complexity			
Technical complexity (6 items)	0.602–0.802	0.925	0.886
Environmental complexity (8 items)	0.765–0.898	0.885	0.752
Organisational complexity (5 items)	0.721–0.882	0.912	0.864
Intra-organisational complexity (3 items)	0.694–0.782	0.945	0.821
Absorptive capacity			
Exploration (4 items)	0.685–0.887	0.91	0.892
Assimilation (3 items)	0.723–0.878	0.896	0.795
Transformation (5 items)	0.665–0.759	0.856	0.802
Exploitation (3 items)	0.736–0.841	0.944	0.887
All factor loadings were significant at P<0.001			

5- Analysis and research findings

5.1 Transforming data into fuzzy sets

In the fsQCA method, causal conditions (absorptive capacity and project complexity) are both represented by means of fuzzy set scores (Ragin, 2009). To transform the conventional factors into fuzzy membership scores, the factors were calibrated for their level of membership sets of different cases in order to generate scores ranging from 0.00 to 1.00 (Ragin, 2008b). The interval scale factors were converted into fuzzy set membership scores by means of the fsQCA software calibrating function (Ragin, 2008b) in line with the process detailed by Ragin (2008a). To calibrate factors, the experts defined values of interval scale factors corresponding to three main qualitative anchors to structure the fuzzy set (Ragin, 2009): full membership threshold (fuzzy score=0.95), full non-membership threshold (fuzzy score=0.05), and cross-over point (fuzzy score=0.5). The highest ambiguity is found if a case is more in or more out of the set (Ragin, 2008b). In order to specify such qualitative anchors, we provide a rationale for each breakpoint (Ragin, 2009). To match the fuzzy set calibration with the five-point Likert scales utilized in this research to measure absorptive capacity and project complexity, we set original values (Table 7) of 5.0, 1.0, and 3.0 corresponding to full membership, full non-membership, and cross-over anchors, respectively.

Table 7- Anchor points to calibrate variables measured by Likert scales

VARIABLE	RANGE	FULL NON-MEMBERSHIP	CROSS-OVER POINT	FULL MEMBERSHIP
TECHNICAL COMPLEXITY	1–5	1	3	5
ENVIRONMENTAL COMPLEXITY	1–5	1	3	5
ORGANISATIONAL COMPLEXITY	1–5	1	3	5
INTRA-ORGANISATIONAL COMPLEXITY	1–5	1	3	5
EXPLORATION AC	1–5	1	3	5
ASSIMILATION AC	1–5	1	3	5
TRANSFORMATION AC	1–5	1	3	5
EXPLOITATION AC	1–5	1	3	5

5.2 Analysis of necessary conditions

To understand if any of the eight conditions are important for implementing co-development, we studied if the condition is usually present or absent in all of the cases in which a result is present or absent across all NPD projects phases (Ragin, 2008a). In addition, relationship performance is reachable if the condition in question (co-development) takes place (Fiss, 2007). Thus, consistency scores were scrutinized; they can measure the level to which observations are in line with this specific rule (Schneider et al., 2010). The more that observations fail to fulfil the rule for critical conditions, the consistency score will be lower as well (Ragin, 2006). A single condition could be assumed as important if the corresponding consistency score is more than the threshold equal to 0.9 (Schneider et al., 2010; Wagemann & Schneider, 2010). In this study, for companies that take a co-development approach, consistency scores for the presence of results (co-development presence) ranged from 0.9 to .094. All conditions were tested, and they were more than the needed threshold, but eight conditions (both their absence and presence) are critical to implement co-development in NPD projects.

5.3 Constructing the truth table

Four truth tables were designed via fsQCA software with a causal result, which was co-development for each phase of NPD. Ragin (2008b) notes that gaps in high consistency values are helpful to generate a consistency threshold, and those less than 0.75 demonstrate substantial inconsistencies. According to guidelines, the threshold consistency was 0.90 for each truth table. Besides the consistency value condition, configurations with two or more cases were considered in the final phase of analysis.

5.4 Research findings

The fsQCA software provides three key solutions: 1) the complex solution (zero logical remainders utilized), 2) the intermediate solution (considers logical remainders, which make sense for a final solution), and 3) the parsimonious solution (all of the logical remainders might be utilized, with no assessment of possibility). The intermediate solutions are better compared to others, since they do not permit removal of any important conditions (Ragin, 2008b); as a result, these solutions were selected in this research. Table 8 shows the intermediate solution with co-development approach implementation in the different phases of NPD as the result. Black circles show that causal conditions are present, and white circles show that causal conditions are absent. Blank cells show that 'doesn't matter' conditions are present. Regarding the first stage of NPD, this table demonstrates that all of the solution consistency values are more than 0.9, which means that these configurations are efficient to implement co-development as the dominant mode of external collaboration.

Solution coverage in the first phase of NPD process was equal to 0.85, indicating that this solution defines a large amount of this kind of external collaboration (Ragin, 2008b). Regarding raw coverage, the more the raw coverage is, the larger the amount of co-development implementation, which is explained by configuration. Configuration 1 demonstrates that firms result in co-development in the first stage of NPD projects while dealing with high organizational and technical complexities as well as limited exploitation and exploration absorptive capacities, even if the firm has sufficient levels of transformation and assimilation absorptive capacities. It shows the key role of organizational and technical complexity, which is plausible due to the complexity and issues in the idea generation stage of NPD.

Configuration 4 has the maximum raw coverage; it shows the presence of environmental, technical, and inter-organizational complexity as well as the absence of organizational complexity, along with high levels of exploitation and assimilation capacity and low levels of transformation and exploration capacity. This will lead to initialization of co-development in the first stage of NPD projects. It explains that if a firm is dealing with environmental, technical, and inter-organizational complexity and does not have sufficient capacity to transform and explore external knowledge, it would be better to set up a co-development partnership to ensure the firm is properly collecting and using its external knowledge to generate ideas to develop a new service or product.

The results in Table 4 reveal that the presence of many main determinant variables are critical to implementing co-development strategy in the first stage of an NPD project. The most necessary variable is technical complexity, which is important for all of the configurations. The other needed variable is exploration absorptive capacity, which is present in both configurations and has a key role for a firm in establishing co-development strategy. Table 8 provides a summary of intermediate solutions, with co-development strategy implementation as the results in different stages of NPD projects.

Table 8- Intermediate solutions with partnership in different stages of NPD as a causal outcome

	IDEA GENERATION (1ST PHASE)		DESIGN (2ND PHASE)		PRODUCTION (3RD PHASE)			COMMERCIALIZATI ON (4TH PHASE)	
	Configurations		*Configurations*		*Configurations*			*Configurations*	
	1	**4**	**2**	**4**	**1**	**2**	**1**	**2**	**5**
			Complexity						
TECHNICAL	●	●	●	●	●	○	○	○	○
ENVIRONMENTAL	○	●	○	○	●	○	●	○	●
ORGANISATIONAL	●	○	○	○	●			○	○
INTRA-ORGANISATIONAL	○	●		●	○	●	●	●	●
			Absorptive capacity						
EXPLORATION	○	○	●	●	○	○	○	○	○
ASSIMILATION	●	●	●	●		●			●
TRANSFORMATION	●	○		○	●	○	●		●
EXPLOITATION	○	●	○	●	○	●	○	●	○
RAW CONSISTENCY	**0.94**	**1**	**0.9**	**0.94**	**0.94**	**0.96**	**0.92**	**0.9**	**0.97**
RAW COVERAGE	**0.29**	**0.35**	**0.18**	**0.22**	**0.25**	**0.34**	**0.25**	**0.35**	**0.18**
UNIQUE COVERAGE	**0.01**	**0.02**	**0.01**	**0.02**	**0.04**	**0.01**	**0.02**	**0**	**0.03**
SOLUTION COVERAGE:	**0.85**		**0.89**		**0.88**			**0.86**	
SOLUTION CONSISTENCY:	**0.91**		**0.94**		**0.90**			**0.94**	

configuration 4, which has the maximum raw and unique coverage in the solution, shows that the presence of inter-organizational and technical complexity as well as the absence of transformation capacity can result in the establishment of a co-development strategy. In comparison with configuration 4, configuration 2 shows that lower levels of exploitation capacity on their own could result in greater possibility to implement co-development. This is logical, since if an organization is dealing with technical complexity and does not have sufficient capacity to exploit some external knowledge, it should develop forms of external collaboration with higher levels of knowledge transfer and communication.

Table 8 also provides a summary of intermediate solutions and implementation of co-development as the result in the third stage (production) of NPD projects. Technical complexity is the most critical variable in this stage of NPD, and it is present in both configurations as a causal condition to consider co-development as the key mode of open innovation in the third stage of NPD projects. In configuration 1, excluding technical complexity, inter-organizational, and environmental complexities together with limited exploitation and exploration capacities are important conditions to implement co-development in the third stage of projects. However, in configurations 2, organizational complexity is not a critical variable, and in these same configurations, limited transformation and exploration capacities as well as inter-organizational complexity are the most effective variables to force firms to apply co-development strategy in the third stage of NPD projects.

Table 8 summarizes intermediate solutions considering co-development strategy as the result of the last stage (commercialization) of NPD projects. The table also shows that the consistency value is more than 0.9, demonstrating that such configurations have enough conditions for co-development strategy implementation in the fourth stage of NPD projects. Inter-organizational complexity and limited exploration capacity are two key variables that are available in all of the configurations, and they are causal conditions to implement co-development in the commercialization stage of NPD projects. Configuration 1 reveals that environmental complexity should be present with the inter-organizational complexity and no exploitation and exploration capabilities to implement a co-development strategy in this stage of an NPD project. In the case of configuration 2, the firms with high levels of exploitation capacity and no exploration capacity use a co-development strategy while dealing with inter-organizational complexity in the commercialization stage of NPD projects. Finally, regarding configuration 5, with maximum raw consistency and optimum coverage, it can be seen that environmental and inter-organizational complexities make firms set up partnerships with external sources of knowledge in order to improve exploitation and exploration capacities.

6. Discussion

The literature review reveals that looking deeply across a broad range of search channels can suggest some resources and ideas that aid companies in achieving and understanding innovative opportunities (Chen et al., 2011; Laursen & Salter, 2006). However, there is one precondition to successfully commercialize and internalize the achieved knowledge from external source collaborators, which is having the required absorptive capacity to first realize the present value in knowledge and assimilate and use it for commercial ends (Ferrears-Mendez et al., 2015; Spithoven et al., 2011). This research suggests this idea according to investigations employing Cohen and Leventhal's conception regarding absorptive capacity, which explains that more internal absorptive capacity can allow companies to capitalize on external innovation sources (West & Bogers, 2014). However, past investigations reveal different predictions regarding the aforementioned impact. Some studies conclude that absorptive capacity can decrease the necessity of collaboration, but on the other hand, some investigations reveal that absorptive capacity can increase the chance of companies looking for collaboration (Ferraras-Mendez et al., 2015; West & Bogers, 2014, p. 821). Current research provides more knowledge on the above-mentioned conflicting point of view, with presenting the project complexity as the antecedent to develop external collaboration (Gheshmi et al., 2018) and also its configuration with various aspects of absorptive capacity in different stages of NPD projects and shows that absorptive capacity as an important variable, play rols in different phases of NPD projects in order to implement deep collaborations with external knowledge sources.

6.1 Theoretical implications

The results of this investigation show that maintaining good relationships with agents across different levels of NPD can help companies to expand the pool of market and technology opportunities to improve their capabilities to solve complex issues. Since such a collaboration requires a two-way learning interaction, it offers companies sufficient flexibility to leave external sources, based on the relevance of the knowledge base of the collaborator and potential advantages that the company might achieve from it across different phases of NPD. However, while companies should obtain some tacit or knowledge from external contributors in commercialization and production objectives and are dealing with limited exploration absorptive capacity, so keeping deep and close relationships with external contributors might help them to provide necessary truth to facilitate information recognition outside their own boundaries and decrease environmental, technical, and inter-organisational complexities.

Although the strategy of a company is to maintain new assimilated knowledge and then implement it to generate ideas and dealing with environmental and technical complexities, findings explain that companies need to initiate stable collaborations with their external sources. Since such service and collaboration are significantly individualized and oriented to the company, organisations should maintain good collaborations in order to facilitate assessment of the initial idea and solve deficiencies that might arise prior to implementation. This might reveal why broad developing collaborators do not have any significant impact on transformative absorptive capacity. There is a relation between transformative absorptive capacity and deep knowledge search strategies in two stages of NPD: idea generation and production. Therefore, firms should choose what type of knowledge to keep in their knowledge base for future applications. Such a process might be ambiguous, because it is difficult to predict the future value of any kind of knowledge (Daft & Lengel, 1986; Spinthoven et al., 2011). Hence, it can be more helpful for companies to retain good relationships with a few collaborators to determine what knowledge to keep and these close relationships should obtain the most optimum degree where knowledge expenditure, time and resources used not to be more than advantages of relationship.

Our research demonstrates that co-development is developing as the dominant mode of external collaboration strategies when companies prefer to use exploitative knowledge of absorptive capacity to improve current processes and products or create totally new ones, across idea generation, design as well as production phases and they are facing with high level of intra-organizational and technical complexity. If a certain type of knowledge and its potential source have been recognized, then a company might need to maintain higher levels of formal collaboration with such agents. The main reason is that formal collaboration will help create interactions patterns and mutual understanding among collaborators, which is important to dismiss the uncertainties of collaborators to appropriate shared knowledge (Laursen & Salter, 2014).

Even though external knowledge openness helps companies to improve their innovation results, previous studies show that over-search might hinder a company's innovation performance level (Ahuja & Katila, 2001; Laursen & Salter, 2006). Current research follows past findings and confirms that reduce the innovation level in a company might be relevant to absorptive capacity insufficiencies. For example, optimistic insight of managers who focus on openness while exploring the context for new ideas (Laursen & Salter, 2014) might hinder them from understanding the necessary structures to improve deep connections or search channels. Hence, having deeper levels of collaboration rather than number can result in some issues for companies to understand the potential value in new sources of knowledge, transfer such knowledge in an organisation, and reduce the level of project complexity. In addition, while a company decides to transform and use such new knowledge, over-search might become counterproductive due to increased knowledge redundancy or use of proper mechanisms. Because the retained knowledge by companies at this level is more market-applied and explicit, there would be a high risk that it might spill over to the market. Thus, the number of external collaborators and the low depth connections might lead to more limited mechanisms to guarantee profit that will slow down the ability of a company to match market opportunity and knowledge.

6.2 Managerial implications

From practical point of view, this study explains the management's considerations in developing partnership strategy as the dominant mode of external collaboration in order to improve their absorptive capacity and decrease project complexities level. To create a competitive advantage, managers should generate strategies that lead to synergies among external knowledge search and transformation, assimilation, and exploitation of knowledge in order to minimize or remove any complexity in each phase of NPD projects. Such strategies are necessary, since deficiencies in any NPD stage might be as significant as a total lack of absorptive capacity (Argote et al., 2003; Marsh & Stock, 2006). The managers need to provide balance between the breadth and intensity of relationships based on which phase of the NPD project they are in and what type of complexity they are dealing with. For example, while the emphasis is on idea generation and the firm does not have sufficient explorative absorptive capacity and also is dealing with environmental and technical complexity, the attention is better to be on generating a context which improves both intensity and scope of collaborations in order to improve knowledge base of the company, successfully. If firms commercialize products and are dealing with intra-organisational and environmental complexities, they should promote exploitative and explorative absorptive capacity by initiating deep collaboration with sources of knowledge. These findings are in line with previous studies (Koput, 1997).

6.3 Limitations and future research

This research has some limitations that provide guidelines for future studies. First, data were collected at one point, which prevented us from analyzing causal relations between studied variables. A longitudinal study might provide more insight into the dynamics of learning procedures and how they permit a company to create a competitive advantage from external sources of knowledge. Another limitation is knowledge sources operationalization. In this study does not consider sources of collaboration as well as actors that might be chosen by company in order to set up partnership. Future investigations mentioning the explained limitations should be conducted. More lines of study on performance can be added to these analyses. Such studies will help to determine if co-development with various knowledge sources across NPD projects will have different results. Such investigations will also contribute at all levels of analysis and test other organizational and individual variables (Lewin et al., 2011; Volberda et al., 2010).

7. Conclusion

This research examined the role of project complexity and absorptive capacity in implementation of co-development as the dominant mode of external collaboration across the NPD project stages. It revealed various project complexities that force these firms, with lack in absorptive capacity to implement codevelopment in NPD process phases.

Exploration, assimilation, transformation, and exploitation are the absorptive capacities that should be improved by generating co-development as the key mode of external collaboration in order to help firms decrease the complexity level. In particular, we assert that through implementing the co-development strategy in NPD projects, firms can improve the absorptive capacity level and minimize various project complexity dimensions. This approach can decrease environmental and technical complexities in the first stage of NPD projects and generate transformation and exploration absorptive capacities for organizations. Moreover, in the design phase in NPD, firms are able to minimize their intra-organizational and technical complexities and improve their exploration absorptive capacity level by creating deep relationships with external sources of knowledge. In the third stage of NPD (production), firms deal with technical complexities; if they lack transformation and exploration absorptive capacities, the best method is to initiate strong relationships with external parties. Finally, in the commercialization phase, firms deal with environmental and intra-organizational complexities. In order to solve them, they should improve their exploitation and exploration capabilities.

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Chapter 4

Configurational paths to NPD project performance- Involving source of innovation in project phases

Abstract

The open innovation and project management literature has primarily focused on particular partner types, for example, supplier relationships, customer participation or competitor interaction. This article explores the nature and role of different types of interfirm relationships for new product development (NPD) success. The underlying premise of the study is that not only the type of interfirm relationships but also the combination of relationships is important for different dimensions of NPD performance. The interaction with a specific type of partner is expected to influence project performance by means of appropriate knowledge transfer. Varying needs for external knowledge in each phase of NPD project, and thus types of knowledge source, are observed as the significant factors to achieve specific type of project performance in the NPD process. Cost, Market, Speed and product novelty are those dimensions of the project performance which are considering in this study. The article is based on data from 125 NPD projects in Spanish low knowledge intensive SMEs, which was gathered in 2018 through in depth interviews by CEO and R&D directors. The article explores 2 configurations of involving different knowledge sources (Suppliers, Customers, Universities and Competitors) in different phases of NPD projects to achieve to the cost performance. With 3 configurations company can advance the projects in shorter time. To have market performance, the companies used just one configuration by involving universities and customers in the first, second and the last phase of the project and finally to obtain product novelty, companies will be able to involve different knowledge sources in 2 different ways. The article is concluded by a discussion of the implication of this finding for building knowledge within the firm and for selecting external partners for NPD.

Keywords—Open innovation, supply chain management, absorptive capacity, project complexity, co-development, fsQCA, new project development

1 - Introduction

The need to support innovation through contributions from external sources of knowledge, for example customers or providers, is not a new topic (Allen, 1977; Allen et al., 1980; Clark & Fujimoto, 1991; Eppinger, 2001; Katz & Allen, 1982; Morelli et al., 1995; Trott & Hartmann, 2009; Tushman, 1979). During the past 20 years, knowledge integration and the product development process have been seen as two critical strategies for a new product development process (NPD; Barczak, Griffin, & Kahn, 2009; Gerwin & Barrowman, 2002). The two aforementioned strategies were the main focus of both industry and academicians (Clark & Fujimoto, 1991; Griffin, 1997b; Hauptman & Hirji, 1996; Zirger & Hartley, 1996), as well as many practitioners (Clausing, 1994; Imai, Nonaka, & Takeuchi, 1985). Recently, the emphasis on open innovation has been changed (Chesbrough, 2006; Gassmann, 2006; Kirschbaum, 2005; van de Vrande et al., 2009). The concept of open innovation is described as "using purposeful knowledge inflows and outflows to respectfully improve internal innovation and expanding the market for external exploitation of innovation [Chesbrough, (2003a)]". In the current study, we emphasize the inbound flow of knowledge from external resources. Most of the studies on collaborative innovation and external collaboration have tried to get an understanding of what constitutes a sufficient number of external partners (Laursen & Salter, 2006), as well as the critical role of various external sources (Faems et al., 2005; Lau et al., 2010; Un et al., 2010). The most significant similarity among these investigations is that the studies have been performed at organizational level, which means that collaborating and searching are considered to be a whole organization decision rather than a decision according to the requirements of particular NPD projects. Only in a few cases have the impacts of various external resources at project level within an open innovation context been investigated (Bahemia & Squire, 2010; Tranekjer & Sondergaard, 2013). To the best of our knowledge, there are few studies on the impacts of various external resources at NPD project level within an open innovation context. The main premise of this research is that both relationships with external knowledge resources and a combination of many relationships in all NPD phases are critical for new product development performance. Researchers have noted that product development practices need to be dependent on complexities and features of projects (Fitzsimmons, Kouvelis, & Mallick, 1991; Gerwin & Susman, 1996; Gheshmi et al., 2019; Griffin, 1997b; Krishnan & Ulrich, 2001; Langerak et al., 2008; Olson et al., 1995; Olson, Walker, Ruekert, & Bonnerd, 2001; Zirger & Hartley, 1996). Each single phase of new product development projects has unique features that make that project different from other projects and phases, thus, having any kind of implementation with external sources of knowledge should be compatible with such features.

The problem here is about NPD analysis at project phase level for contributing to previous studies on open innovation with a more detailed and comprehensive view of the existing relationship between various external sources in innovative performance and NPD phases. It can be done through studying the combination of external sources in project phases and their relationship with project-level performance. It is suggested that analysis of project phase level can offer a more accurate and varied picture of innovative functions in organizations and also their impacts than studies conducted on project or organization level (Molina-Castilo & Munuera-Aleman, 2009).

Due to the fact that new product development projects can be assessed on different aspects, we have added related performance measures to market performance, speed and cost (Huang et al., 2004). The key goal is to offer a more comprehensive view on the relationship between combinations of external knowledge sources and project phase-level performance.

The research question is as follows:

- Which configurations of involving knowledge sources in different phases of NPD, can improve project performance?

This article will continue by discussing previous studies that support research gaps and also developing hypotheses in Section 2. Then, in Section 3, variables and methods will be described, while descriptive results and findings achieved by ordinary least squares regression will be highlighted in Section 4, and finally further conclusions and discussions are presented in Section 5.

2. Review of Relevant Literature

Previous studies on open innovation and interorganizational innovation demonstrate that the contribution of external sources is a key approach to accessing useful knowledge sources for innovation (Chesbrough, 2003b; Knudsen, 2007). The most important benefit gained by previous studies is having access to external knowledge sources and the chance of learning from partners via knowledge transfer (Inkpen & Tsang, 2005; Powell et al., 1996). However, risk and cost sharing are necessary motivational elements of participating in external partner relationships (Faems et al., 2005). A study of previous investigations on innovation external sources at project phase level revealed two gaps that will be presented in this article:

1- Combination of sources rather than isolated sources

2- Collaboration with various knowledge sources in NPD phases

In terms of analysis, few studies have been carried out about the impacts of external sources at project level. Primarily, project level has been utilized in studies on the contribution of one particular partner, such as the involvement of providers in industrial marketing studies/supply chain management (Johnsen, 2009) and regarding studies on customer contribution in the market (Bonner & Walker, 2004; Rindfleisch & Moorman, 2003; Salomo et al., 2003) as well as lead users (Von Hippel, 2005). But in the case of more common impacts of external sources on new product development projects, there are few results (see Hoang & Rothaermel, 2010; Knudsen & Mortensen, 2011). For combining various external sources, these sources are usually studied in larger dimensions, which means that many external sources are involved (Laursen & Salter, 2006), and for individual impact (Faems et al., 2005; Lau et al., 2010), although previous studies show the key role played by combining various sources (Nieto & Santamaría, 2007). The question is that whether using a mixture of different sources is better than using similar types of a single source or not, and if various project phases are crucial elements in mixing sources.

2.1 Sources of knowledge and their combinations in NPD projects

Since the reasons to include external sources to improve competitive advantage and innovative performance are global, the involvement of sources can be defined in many ways (Sofka & Grimpe, 2009). One of the ways to define sources is through considering search breadth or number of sources as explained in Laursen and Salter (2006), who revealed that involving external partners in innovation objectives is of little benefit. The negative impact of too much openness might be that the organization experiences problems of attention allocation while increasing the number of its external partners

(Laursen, 2011) or more marginal costs due to the complexity level (Leiponen & Helfat, 2010). The other method to classify external source involvement is through studying different types of sources. Common external sources studied in previous empirical investigations are customers, providers, universities and competitors. Empirical researches demonstrate important positive impacts of including universities, customers and providers on innovation and negative impacts from including competitors on innovation (Faems et al., 2005; Lau et al., 2010; Nieto & Santamaría, 2007; Un et al., 2010), mainly because of complementary knowledge provided to the central organization. The third method for classifying external sources is through studies that investigate combining external sources.

One study on combining sources together shows that novelty is achievable through a mix of external sources (Nieto & Santamaría, 2007), although it is not quite clear which source combinations are the most helpful. To the best of our knowledge, the study of combinations of sources shows only tentative results regarding a positive effect of combining suppliers and competitors, and a negative effect of combining universities with customers or competitors (Knudsen, 2007). Common to all the studies mentioned and regardless of how sources are classified, they analyse the role of sources at firm or project level where innovative performance is measured as, for example, product innovation and turnover from new products, while there are few studies at the project phase level (Bahemia & Squire, 2010). We argue that investigating the involvement of external sources at the project phase level is just as important, since each phase of an NPD project may require different types of input from different types of external sources, thereby not necessarily benefitting from involving more of the same sources and or involving some sources with (in)compatible knowledge with the ones we need in a particular phase. The involvement of sources is therefore not a one-off event but a decision to be made project by project (Bahemia & Squire, 2010; Bonesso et al., 2011). Existing studies focusing on different types of sources/combinations of sources at the project level focus on either the importance of technology sourcing strategies for NPD projects (Kessler et al., 2000), or the effect of knowledge novelty and diversity on NPD projects (Bonesso et al., 2011), or the role of alliance experience (Hoang & Rothaermel, 2010) with a focus on the science link (Cassiman et al., 2010). Only Knudsen and Mortensen (2011) investigate the effect of increasing openness in NPD projects. The empirical open-innovation literature analysing the involvement and combinations of external sources at the project phase level is thus very limited. This is also pointed out by Bianchi et al. (2011) who propose a conceptual framework for the implementation of inbound open innovation practices in different new product phases in the biopharmaceutical industry. The first aim of this article is thus to investigate how the combination of sources in different phases is related to NPD project-level performance. As the different types of external sources provide knowledge of a different nature (e.g. technological knowledge or information about markets and needs), sources are divided into market and science sources (Sofka & Grimpe, 2009; Vega-Jurado et al., 2009). In this way we break away from the existing studies conducted at the project phase level that only distinguish between applying external sources and not (Bonesso et al., 2011; Knudsen & Mortensen, 2011). We expect market sources to improve product innovation by providing knowledge about needs and markets (Miotti & Sachwald, 2003; Nieto & Santamaría, 2007), and science sources to influence innovation by directing firms towards new technologies as well as new markets (Belderbos et al., 2004; Nieto & Santamaría, 2007) if we can involve more relevant sources in each phase of the project.

In addition to the fact that various sources can provide a variety of knowledge types, a variety of sources might impact on the measurement of different performances in many ways. New product development costs are assumed to increase and it is also expected that speed will be decreased while including both science and market sources, as defined by attention allocation issues (Laursen, 2011). Although such findings are in accordance with organizational-level studies, it can be argued that such issues will happen at project level and project phase level. Moreover, according to project level researches, including external sources rather than not including them might reduce speed and increase costs (Knudsen & Mortensen, 2011). Earlier investigations on NPD projects demonstrated that costs might increase due to more coordination attempts and speed is decreased as a result of added effort to integrate external knowledge (Kessler et al., 2000). Novelty level and market performance, such as sales and profits, are considered to be improved through combining science sources and market in accordance with the idea that various sources suggest various knowledge types and the fact that the provided knowledge is able to complement an organization's core knowledge and direct the organization into new markets, resulting in higher levels of novel innovation (Nieto & Santamaría, 2007). All of these outcomes could be different by considering in which project phase such collaborations will be established.

2.2 Literature on project characteristics (uncertainty and complexity)

Both complexity and uncertainty in previous studies have been defined as two important NPD project characteristics that impact on performance (Clark & Fujimoto, 1991; Eisenhardt & Tabrizi, 1995; Fitszimmons et al., 1991; McDonough, 1993; Tatikonda & Rosenthal, 2000a, 2000b). Literature has revealed that complexity and uncertainty make new product development projects complicated and can have negative effects on NPD performance. But empirical proof that can support this idea is still indeterminate. Although many empirical investigations have analysed the relationship between NPD performance and uncertainty, the results achieved from these researches are often not comparable and contain contradictions due to the inconsistency of the measures used. Simultaneously, the relationship between NPD performance and complexity is still not clear (Griffin, 1997b; Jacobs, 2007).

Many technologies have been employed to describe uncertainty and complexity, including task difficulty (McDonough, 1993), content and scope (Clark, 1989), market and product newness (Booz Allen Hamilton, Inc., 1968), technology competition and changes, high rates of growth (Eisenhardt & Tabrizi, 1995), the TOEI framework (Gheshmi et al., 2019) and technology novelty (Larson & Gobeli, 1989; Tatikonda & Rosenthal, 2000a), and presented various project complexity aspects in the open innovation field. In addition, these investigations utilize a broad range of performance measures as their dependent factors, making it hard to provide reasonable conclusions from studies. An analysis of 546 NPD projects performed by Larson and Gobeli (1989) could not identify any specific relationship between technical performance and uncertainty, schedule, cost and overall results. In the current research, uncertainty was measured through technology novelty. Another investigation on 32 small product development projects could not reveal any specific relationship between the speed of product development and technology familiarity (McDonough & Barczak, 1992). But another study that used a similar sample revealed that technical difficulty has a negative impact on product development speed (McDonough, 1993).

To sum up, there is an ongoing major theoretical discussion claiming that project complexity and uncertainty have negative effects on new product development performance; however, there is little evidence to support this argument. A study on 17 published articles (Gerwin & Barrowman, 2002) could not identify a relationship between development time reduction and low uncertainty. But, through dividing the sample into two specific groups according to the performance metric used (development time goal and development time), studies on eight published articles showed that there is a relationship between development time and incremental approach, while nine studies could not show any relationship between development goal and incremental approach.

3. Configuration theory and analyses

3.1. Configuration theory

Configuration theory is a technique used to understand how organizational structure is related to strategic intent (Hult, Ketchen, Cavusgil, & Calantone, 2006). This theory was initiated in literature (Miller, 1996) and explains that for any particular context, specific organizational configurations of structure and strategy can fit more efficiently than other configurations, whichs lead to improved performance (Dess et al., 1993; Meyer et al., 1993). If the fit between strategy and structure is strong enough, the performance improves (Vorhies & Morgan, 2003). Also, Meyer et al. (1993) defined organizational configuration as any type of multidimensional facet of conceptually specific characteristics that occur together, rather than seeking global relationships that are the same in various firms; this theory explains that relationships can be understood better in corresponding conditions (Vorhies & Morgan, 2003). Moreover, an appropriate set of factors or conditions usually cannot lead to better performance (Doty et al., 1993). The main emphasis of configuration theory asserts that strategy and structure factors generally provide a small number of manageable configurations, Gestalten and archetypes, that demonstrate a huge number of high-performance firms (Miller, 1986, 1996). Thus, there are many successful techniques. Meyer et al. (1993) explained:

If firms were complicated amalgams of many attributes that could continuously and independently vary, then there would be infinite possible combinations. However, for configurational perspective theories, there is limited variety due to the tendency of attributes to fall into some coherent patterns. Such patterning takes place since attributes have interdependency and usually change only intermittently or discretely.

Based on the fact that the number of efficient configurations is limited and due to these configurations being composed of a tight formation of mutually supportive variables (Miller, 1986) and almost being long-lasting in nature (Miller, 1986, 1996), applying a configurational perspective can help in studying and defining complex relationships between constructs of different domains without any simplicity of facts in the current study. In our research, the main focus of configurational perspectives is on the structure of a relationship, for example the multidimensional characteristic of a relationship, and on choosing a development strategy or collaboration.

3.2. Operationalizing configuration theory through fsQCA

Set-based techniques such as fuzzy set qualitative comparative analysis (fsQCA) include appropriate tools for providing complementarities and non-linear relationships between different constructs (Ragin, 2000; Woodside, 2010, 2013). Instead of disaggregating a variety of cases into many independent variables, this analysis is able to conceptualize factors as combinations of different attributes manifested by a group of memberships. fsQCA offers knowledge about how various cases combine together to develop a particular result, which generates a huge casual complexity level and describes critical and efficient conditions based on configurational results.

In performing configurational analysis, fsQCA is helpful in order to define external collaboration modes. This configurational analysis employs a pragmatic method to form interdependent cause-effect relationships as proper accounts, demonstrating variance in organizational innovation behaviour (Doty & Glick, 1994; Fiss, 2009, 2011; Short, Payne, & Ketchen, 2008).

This investigation can join complexity and economy together by means of integrating different causal relationships into a few specific profiles (Fiss, 2011). In addition, fsQCA helps to show the difference between critical and sufficient causal conditions for implementing co-development as the key external collaboration mode (Fiss, 2011). If the critical conditions are the attributes demonstrated by each single focal-set member in firms, then sufficient conditions can explain other attribute combinations, resulting in interesting outcomes.

Although a few researches have been carried out, fsQCA has not been used in innovation management studies (e.g. Cheng, Chang, Li, & Woodside, 2012; Cheng, Chang, & Li, 2013; Froesen, Luoma, Jaakkola, Tikkanen, & Aspara, 2016; Ganter & Hecker, 2014; Ordanini, Parasuraman, & Rubera, 2014; Schneider, Schulze-Bentrop, & Paunescu, 2010; Tóth, Thiesbrummel, Henneberg, & Naudé, 2015). It is surprising that there is limited focus on this topic because complex patterns of causal relationships between contributing factors, innovation activity and success, and also causal asymmetry, are dependent on a broad range of factors in innovation analyses.

4. Research and method design

4.1. Data sources

Spanish organizations with limited intensive knowledge and one NPD project at least, in a variety of industries over the last two years, are taken as the sample population of the study. Both primary and secondary data sources were gathered and data construct validity was confirmed according to triangulation rules (Greene, 1990). A range of individual detailed interviews with organizations were performed (CEOs and R&D), together with the process outlined by Yin (2009) and Eisenhardt (2007). These interviews were performed to emphasize NPD projects and different kinds of external collaboration (with a focus on frameworks of open innovation), as well as absorptive analysis of organizations through semi-structured questions and face-to-face interviews. These interviews were performed by corresponding individuals (CEOs and R&D directors) in any organization together with some telephone interviews as a follow-up. Each single interview took 60 to 100 minutes. All of them were transcribed and recorded and a database was established in order to ensure data validity. Overall, more than 30 hours of recording and 250 pages of transcript were gathered from 2017 to 2018. After performing each interview, a transcript copy and case report were sent to respondents to control errors and ensure the validity of gathered data. T-test analyses revealed that there was no significant difference between these groups in the answers they provided, showing that there was no systematic difference between early and late given answers. Most of the participants were men (66%), with 33% being aged from 36 to 40 while 26% of them were aged from 31 to 35. With regard to their level of education, 0.4% had a diploma, 17% had a college degree, 45% held a bachelor degree, 33% had a master degree and almost 5% had a PhD. The collected data were triangulated with information obtained from different observational and secondary sources, such as firm websites, online reports and information, websites, tweets, materials presented by informants (archival data, internal memos and company brochures) and also news to confirm the research (Greene, 1990). In addition, to gather more information on particular variables (absorptive capacity), questionnaires were distributed to the same respondents.

4.2. Case firm selection

In accordance with Eisenhardt (1989), a multiple-case design was employed that comprised 125 new product development projects from a total of 85 manufacturing firms within eight different industries in Spain. Also, for case selection, the replication logic presented by Yin (2009) was employed. This information-oriented technique was considered in order to improve the exploitation of information from small samples and simple cases (Patton, 2002).

In accordance with the nature of the current study and also the literature on NPD and open innovation, our main criteria for selecting firms were:

(1) operating in a low knowledge-intensive industry;

(2) having at least one new product development project during the past two years;

(3) using external sources of knowledge for NPD processes;

(4) having no more than 250 employees;

(5) having a turnover of no more than 50 million euros annually.

For developing the maximum variation between these cases, firms of various ages, sizes and also technological levels were chosen.

4.3. Data collection

The unit of analysis is a phase of the NPD project that has a narrow description: for instance, covering all of the activities from the beginning to the end including the proposal, initiation, design, development, execution, implementation and finally commercialization.

In accordance with the protocol, a total of 85 semi-structured interviews were performed with the R&D directors, representatives or general managers of 125 projects. During these interviews, open questions were asked about the different knowledge sources that they used in each project phase to understand the most efficient knowledge source to use as external collaboration in phases of NPD projects.

Both inductive and deductive methods were employed in this research to understand the cases effectively and define the meaning of theoretical aspects (Eisenhardt, 1989). In addition, both cross-case and within-case analyses were utilized. In this regard, within-case analysis includes the definition for each particular case within its context. It is a critical aspect of studying each case to obtain useful insight and knowledge (Eisenhardt, 1989).

5. Analysis and research findings

5.1. Transforming data into fuzzy sets

In the fsQCA approach, the causal conditions, including project complexity and absorptive capacity, are both explained by means of fuzzy set scores (Ragin, 2009). In order to transform conventional variables into scores of fuzzy membership, we calibrated the variables for the membership set level of various cases to obtain scores ranging from 0.00 to 1.00 (Ragin, 2008b). Also, interval scale variables were converted to fuzzy set membership scores via fsQCA software that calibrates functions (Ragin, 2008b) together with the detailed process of Ragin (2008b). In order to calibrate variables, scholars introduced interval scale variable values that correspond to three key qualitative anchors for structuring the fuzzy sets (Ragin, 2009): crossover point (fuzzy score = 0.5), full non-membership threshold (fuzzy score = 0.05) and full membership threshold (fuzzy score = 0.95). A high ambiguity is identified if a case is more out of or more in sets (Ragin, 2008b). For defining these qualitative anchors, we suggest a rationale for each single breakpoint (Ragin, 2009). In order to match the calibration of fuzzy sets by means of the five-point Likert scale used in this study to evaluate project performance, original values were set (Table 1) of 5.0, 1.0 and 3.0, respectively, for full membership, full non-membership and cross-over anchors.

Table 9- Anchor points to calibrate performance variables measured by Likert scales

variable	range	full non-membership	cross-over point	full membership
cost	1–5	1	3	5
1 cost compared to industry standard				
2 cost compared to expectations				
3 cost compared to typical npd project in firm				
speed	1–5	1	3	5
1 speed compared to what is usual in industry				
2 speed compared to expectations				
3 speed compared to typical npd project in firm				
market performance	1–5	1	3	5
1 growth in product category sales?				
2 revenues?				
3 profits?				
product novelty	1–5	1	3	5
1 product was innovative- first of its kind				
2 considered by customers as being a better product compared to products of competitors (ranekjer and sondergaard, 2013)				

5.2. Analysis of necessary conditions

To identify whether including any type of knowledge source in the new product development process is necessary for project performance, we investigated whether the condition is absent or present in all cases in which an outcome might be absent or present in all phases of NPD projects (Ragin, 2008a). Moreover, a relationship performance can be achieved if the questioned condition (various aspects of project performance) occurs (Fiss, 2007). Therefore, consistency scores have been scrutinized. They are able to assess the extent to which observations are aligned with certain principles (Schneider et al., 2010). If the observations fail to achieve critical condition rules, the consistency score will decrease (Ragin, 2006). A certain condition can be assumed to be necessary if the related consistency score is above the threshold of 0.9 (Schneider et al., 2010; Wagemann & Schneider, 2010). In this research, for firms that have a cost performance, the consistency scores regarding the presence of results ranged between 0.9 and .094. For speed and consistency, the scores ranged between 0.91 and 0.95 in product novelty and market performance, and consistency scores ranged from 0.92 to 0.96. All of the conditions were examined and they were higher than the required threshold; however, including customers in the second project phase, suppliers in the final phase, universities in the second phase and also the last phase, and finally competitors in the first project phase (both their presence and absence), is not important to achieve project performance.

5.3. Constructing the truth table

Using fsQCA software, four truth tables were designed with causal results that were include different knowledge sources in all of the project phases. According to Ragin (2008b), existing gaps in high consistency values are useful for providing a consistency threshold and those that were below 0.75 showed substantial inconsistencies. Based on guidelines, the threshold consistency was equal to 0.90 for each single truth table. In addition to the consistency value condition, configurations with two or more cases were assumed in the final analysis phase.

6. Results

The aim of this study project is to empirically analyse which knowledge source configuration involvement in all of the NPD projects phases can provide better project performance. Table 2 demonstrates that the following explanations of empirical studies and findings are related to the study to identify possible configurations. So the firms can choose from them in every NPD project phase to achieve optimum performance level in many aspects, such as speed, cost, product novelty and market.

6.1 Patterns of knowledge source environment

According to predictions, the amount of collaboration between various knowledge sources with various functions is different in project phases. This means that various functions are considered to have a key role in resolving various types of uncertainty and complexity at different NPD project stages. Therefore, being dependent on an internal functional department as well as its interest in collaborating with other sources of external knowledge seems to be different in different NPD project stages. As predicted, levels of external collaboration with sources of external knowledge have been increased in both early and late NPD process phases, in which organizations should have higher knowledge levels to identify new ideas and also commercialize newly developed products in a variety of markets. Clients and suppliers are two key knowledge sources who offer important knowledge to present ideas on how firms can provide new products as well as contributing to firms in choosing a useful strategy to launch products in various markets. In both production and design phases, competitors and universities are more present in external collaborations that have been implemented by companies.

6.2 Patterns of knowledge source involvement and project performance

To investigate whether various patterns of collaboration with external sources of knowledge in NPD project phases are dependent on project performance, we performed many configurations to assess collaboration with knowledge sources in four NPD project phases and the impact on four project performance dimensions.

6.2.1 Configurational path to cost performance

Two configurational paths are defined with a solution consistency of 0.95 and solution coverage of 0.86 that result in efficient cost performance for projects. In the first configuration, customer involvement is identified in both the first (idea generation) and last (commercialization) phase, while in the second phase (design), supplier involvement is identified. The raw coverage and raw consistency are respectively 0.28 and 0.92 in this configuration, which has a particular coverage equal to 0.02. The next configuration, with a raw consistency equal to 0.9 and raw coverage equal to 0.31, revealed that including customers in the last NPD project phase (commercialization) and also competitors in the third NPD project phase (production) might bring efficient knowledge for firms in order to decrease NPD project costs. The solution coverage is 0.84 and the unique coverage is equal to 0.01 for this configuration. Moreover, its solution consistency is 0.95, which means this configuration involves external sources of knowledge and has a significant impact on cost reduction in NPD projects.

6.2.2 Configurational path to speed performance

The findings revealed that if firms are interested in a shorter time to market for new products, three configurational paths can be developed to achieve efficient results. The first path, with a raw coverage 0.29, unique coverage of 0.03 and raw consistency of 0.95, demonstrates that including customers in both the first and last NPD project phase has a remarkable impact in terms of increasing project speed. The second path to market performance is suggesting to involve customers icustomers in the last phase and second phases and also collaborate with competitors in the first phase of NPD process. The raw consistency, raw coverage and unique coverage of the configuration are 0.9, 0.19 and 0.02, respectively. In addition, the last configuration reveals that if organizations in the first and second NPD project phases collaborate externally with suppliers and also include customers in the last project phase, they will be able to decrease the time to market of the project. For this configuration, raw consistency is equal to 1, raw coverage is equal to 0.26 and unique coverage is equal to 0.03, and generally the solution consistency is 0.92 while solution coverage is 0.82 for all of these configurations.

6.2.3 Configurational path to market performance

In order to obtain market performance, firms generated a configuration with a solution coverage of 0.88 and solution consistency of 0.89. In addition, raw coverage was 0.35, raw consistency 0.85 and unique coverage was equal to 0.03. The organizations in this configuration collaborate with universities in both first and second NPD project phases and involve customers in the last NPD project phase.

6.2.4 Configurational path to product novelty

If the organizations are interested in having innovative products, there are two choices for them to develop some external collaborations with knowledge sources in various NPD project phases. The first configuration, with a raw coverage of 0.31, raw consistency of 0.88 and unique coverage of 0.02, enables them to include customers in the first project phase. The other configuration involves collaboration with suppliers in both the first and second phases and with customers in the first project phase. Here, raw coverage is 0.25, raw consistency equals 1 and unique coverage is 0.02. Such a configuration with a solution consistency of 0.97 and solution coverage of 0.94 suggests that if firms implement these configurations, they can improve their product novelty level.

Table 10- Configurational path on project performance

Performance	1st phase	2nd phase	3rd phase	4th phase		
Cost	Customers	Suppliers	-----------	Customers	Raw Consistency: 0.92 Raw Coverage: 0.28 Unique Coverage: 0.02	Solution Coverage: 0.86 Solution Consistency: 0.95
	----------	-----------	Competitors	Customers	Raw Consistency: 0.9 Raw Coverage: 0.31 Unique Coverage: 0.01	
Speed	Customers	-----------	-----------	Customers	Raw Consistency: 0.95 Raw Coverage: 0.29 Unique Coverage: 0.03	Solution Coverage: 0.82 Solution Consistency: 0.92
	-----------	Universities	-----------	Customers	Raw Consistency: 0.9 Raw Coverage: 0.19 Unique Coverage: 0.02	
	Suppliers	Suppliers	-----------	Customers	Raw Consistency: 1 Raw Coverage: 0.26 Unique Coverage 0.03	
Market	Competitors	-----------	-----------	Customers Competitors	Raw Consistency: 0.85 Raw Coverage: 0.035 Unique Coverage: 0.03	Solution Coverage: 0.88 Solution Consistency: 0.89
Product Novelty	Customers	-----------	-----------	-----------	Raw Consistency: 0.88 Raw Coverage: 0.31 Unique Coverage: 0.02	Solution Coverage: 0.94 Solution Consistency: 0.97
	Customers Suppliers	Suppliers	-----------	-----------	Raw Consistency: 1 Raw Coverage: 0.25 Unique Coverage: 0.02	

7. Discussion

This study defined two fields in the literature of open innovation as important areas to be Investigated more in NPD project phases. The first was knowledge achieved through a variety of external sources; previous studies show that for the number of actors there is an upper limit, with no ability to identify how to combine sources. The second was the impact of combining project performance. Again the literature strongly emphasized the impacts of external collaboration on overall project performance; however, it did not concentrate on configurational impacts of external collaboration in NPD project phases and their impact on overall project performance. Investigating these two fields in different project phases show that we might contribute to previous studies by demonstrating negative impacts of including a source type that might be circumvented through being combined with other sources and including the source in one or more project phases, while there is no added value in the kinds of knowledge that we are achieving in that particular phase. In addition, we identified configurations of including knowledge sources in NPD project phases that can improve performance. Involving various sources in each project phase has to be in accordance with the type of knowledge that we are seeking and again it is related to NPD project objectives: to minimize costs and also collaborate with customers in both the first and last project phases and suppliers in the second project phase; to obtain better market performance and product novelty, then select various types of configurations and not just collaborate with competitors and suppliers starting point of a project(Li et al 2019; Luo et al 2010; Ledwith& O'Dwyer 2009) .

The empirical findings from research questions about how combining external sources in project phases impacts on project performance in new product development suggest that including the customers in an NPD project will result in better project performance, which is in line with literature that revealed that the customer involvement in new product development projects has a positive impact on better project performance (Faems et al., 2005; Lau et al., 2010; Nieto and Santamaría, 2007; Un et al., 2010).

When customers are involved in a project is more important than just involving customer, in order to achieve better outcomes. According to findings, customers are considered to be a primary knowledge source that can provide critical information in NPD project phases, which is in line with the results achieved by Tranekjer and Sondergaard (2013); however, the results of customer collaboration are different in each project phase. Customer involvement in both the first and last project phases, and combining this with supplier involvement in the second project phase, can decrease project costs, while customer collaboration in the first and last project phases with no collaboration with other sources of knowledge can increase project speed, or customer collaboration in first project phase can improve product novelty level because the customers can provide more market based knowledge for the company who wants to introduce new products to the market (Li et al 2019). These results demonstrate that in order to improve NPD project dimensions it is necessary to have collaboration with many knowledge sources in each phase, while some particular needs are required for knowledge Supplier collaboration can improve speed and product novelty if it occurs in the first and second project phases together with customer collaboration in the final project phase in order to improve speed (LI et al 2019; Luo et al 2010). However, in another configuration, if customer involvement is included in the first project phase together with supplier collaboration, product novelty will be improved (Li et al 2019). Competitor involvement in the third project phase can suggest important knowledge for production, and if in the commercialization phase, such knowledge is combined with customer market knowledge, so project costs can be reduced. In the case of universities that propose scientific knowledge rather than market knowledge, according to the results, their involvement in both the first and second project phases and combining such scientific knowledge with market knowledge gained from customers will improve market and the project's cost performance. These outcomes are in contrast with those achieved by Knudsen and Mortensen (2011), who identified that combining market and science sources can have a negative impact; however, they did not consider these collaborations in new product development projects. The contribution of this study to literature is analysing the data in different project phases as well as decomposing project performance into various dimensions. Therefore, we can choose the most effective configuration to involve many knowledge sources in NPD project phases to achieve the optimum performance. Here, we can show the advantages of combining particular external sources in different phases, which expands the results achieved in the literature at firm and project level (Knudsen, 2007; Knudsen & Mortensen, 2011; Laursen, 2011; Leiponen & Helfat, 2010; Nieto & Santamaría, 2007).

8. Conclusion

The most important conclusion of this study is that the impacts of knowledge source involvement in new product development projects and their impact on project performance are more complicated than just the "more is better" conclusion identified previously in the literature review. Also, the effects of collaboration on performance are related to which source of knowledge, and at what development process stage, is involved. Using integrated product development teams and a concurrent process of product development are considered two important NPD paradigms during the past 20 years. However, their effect on NPD performance has not been identified properly. Most of the previous studies are case-based and conceptual. There are few incomplete studies that empirically investigated these practices because their main focus was on the speed of product development. But speed is considered to be one of many NPD success determinants. Thus, previous studies are inconclusive, with some contradictory results (Gerwin & Barrowman, 2002). This research aims to fulfil this gap in previous studies and makes many contributions to previous studies conducted on NPD and open innovation. Unlike past studies that only concentrated on one NPD performance dimension such as cost or time, this research employed multidimensional performance evaluation and thus offers a better idea of external collaboration impacts and the involvement of various knowledge sources in projects. There was no negative effect of knowledge source involvement on NPD performance as previously noted in literature. Also, this study revealed that there is a positive and significant relationship between NPD performance dimensions and external collaboration. Finally, this research empirically examined the involvement of various knowledge sources in NPD project phases instead of analysing the involvement of these sources of knowledge in firms' project levels.

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Chapter 5

Conclusions

5.1- Conclusions

The aim of this thesis is to explore the implementation of open innovation practices in new product development projects. This chapter summarizes the principle arguments of the thesis: that there are configurational paths for successful implementation of open innovation practices in different phases of NPD projects. And it may be reflected in developing methodologies to build knowledge in the field.

Table 11, summarizes each the contributions of the thesis in relation to the initial objectives. In the following sections there are more details by reviewing the implications of each chapter, along with the limitations of the studies and future lines of research.

Table 11- Summary of conclusions of chapter 2

Chapter 2

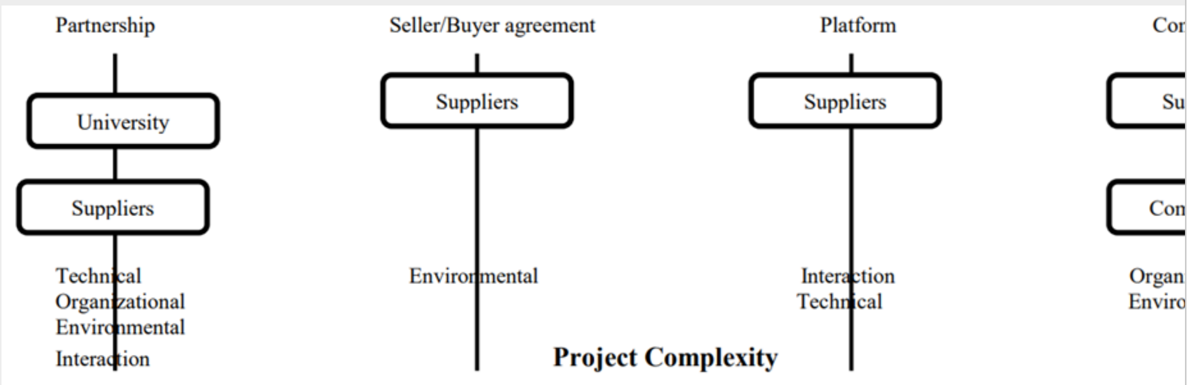
Objective:

Develop an integrate framework for the project complexity and its role in implementation of open innovation practices in NPD projects.

Conclusions:

The TOEI framework has been developed with 28 elements which are classified in 4 categories as Technical, Organizational, Environmental and Interaction complexities. The results of this study show that project complexity is a relevant variable for the companies in developing OIP and involve different sources of knowledge in their NPD process.

Figure 3- Open innovation practices in complex environments



Highlights:

- **Partnership is dominant mode of collaboration in most of the projects. And when the companies faced with different dimensions of project complexities.**
- **Companies will receive more knowledge from their suppliers to reduce the level of complexity.**

5.1.1- Conclusions chapter 2

This chapter provided a framework for defining the external collaboration in NPD projects and the importance of project complexity in strategic decision making process (Van de Vrande 2009; Felin & Zenger, 2014) This framework is based on both empirical data and literature. Using this framework for a certain project provides an understanding of its complexity, indicating potential methods to manage new product development projects more efficiently. The TOEI framework can be utilized to evaluate a project 's complexity and to predefine possible support from external parties. Due to the external collaboration dynamics, we can predict repeated use in different phases of a project.

Applying an inductive method through combining the literature points of view with the elements obtained from30 interviews regarding 15 cases, the TOEI framework provides a broad understanding of project complexity and external collaboration with different knowledge sources in NPD projects. Overall 28 elements were identified, contributing to project complexity in open innovation context in the following 4 areas:

1- Technical complexity,
2- Organizational complexity,
3- Environmental complexity and
4- Interaction complexity.

The number of elements in the framework was not decreased deliberately to explain the richness of project complexity. In the TOEI framework, 4 different levels were identified to facilitate its use: 4 categories known as TOEI, 4 different knowledge sources and 4 modes of external collaboration. It will provide a chance to argue which aspects will make a particular project complex on different levels with different stakeholders and parties involved in the project. This set-up is flexible and allows framework extension, for instance for use in a specific industry. Results of this chapter show that when the companies are facing with project complexities, they prefer to collaborate with suppliers more than other knowledge sources and partnership is the dominant mode of collaboration in most the projects.

5.1.2- Conclusions chapter 3

This research examined the role of project complexity and absorptive capacity in implementation of co-development as the dominant mode of external collaboration across the NPD project stages. It revealed various project complexities that force these firms, with lack in absorptive capacity to implement codevelopment in NPD process phases (Van de Vrande 2009; Felin & Zenger, 2014; Emden et al 2006)

Exploration, assimilation, transformation, and exploitation are the absorptive capacities that should be improved by generating co-development as the key mode of external collaboration in order to help firms decrease the complexity level. In particular, we assert that through implementing the co-development strategy in NPD projects, firms can improve the absorptive capacity level (Emden et al 2006) and minimize various project complexity dimensions. This approach can decrease environmental and technical complexities in the first stage of NPD projects and generate transformation and exploration absorptive capacities for organizations. Moreover, in the design phase in NPD, firms are able to minimize their intra-organizational and technical complexities and improve their exploration absorptive capacity level by creating deep relationships with external sources of knowledge. In the third stage of NPD (production), firms deal with technical complexities; if they lack transformation and exploration absorptive capacities, the best method is to initiate strong relationships with external parties. Finally, in the commercialization phase, firms deal with environmental and intra-organizational complexities. In order to solve them, they should improve their exploitation and exploration capabilities.

Table 12- Summary of conclusions of chapter 3

Chapter 3

Objective:

The objective of this chapter is to see in which conditions, the companies will choose partnership strategy as dominant mode of external collaboration with knowledge sources in each phase of NPD projects, to reduce the level of corresponding complexity and improve the level of different dimensions of absorptive capacity.

Conclusions:

The results show that the configuration of project complexity and absorptive capacity to make partnership with external knowledge sources will be vary in each phase of NPD projects. And there is not just one unique recipe for the companies to implement OIP in their NPD process. Partnership can be a solution for the companies in developing open innovation strategy in their NPD projects, but as we found in this study, there are 3 variables which are contribute in this decision making process. 1- In which phase of NPD they want to make partnership, 2- which kinds of complexities they are facing with and 3- If the level of absorptive capacity in this company is enough to absorb the knowledge.

Partnership will be established when:

1st phase

- **Technical and Organizational complexities and lack in Exploration and Exploitation capacities**
- **Technical, Environmental and Intra-organizational complexities and lack in Exploration and Transformation capabilities**

2nd phase

- **Technical complexity and lack in Exploitation capacity**
- **Technical and Intra-organizational complexities and lack in Transformation and Exploitation capacities**

3rd phase

- **Technical, Organizational and Environmental complexities and lack in Exploration and Exploitation capacities**
- **Intra-organizational complexities and lack in Exploration and Transformation capacities**
- **Environmental and Intra-organizational complexities and lack in Exploration and Exploitation capacities.**

4th phase

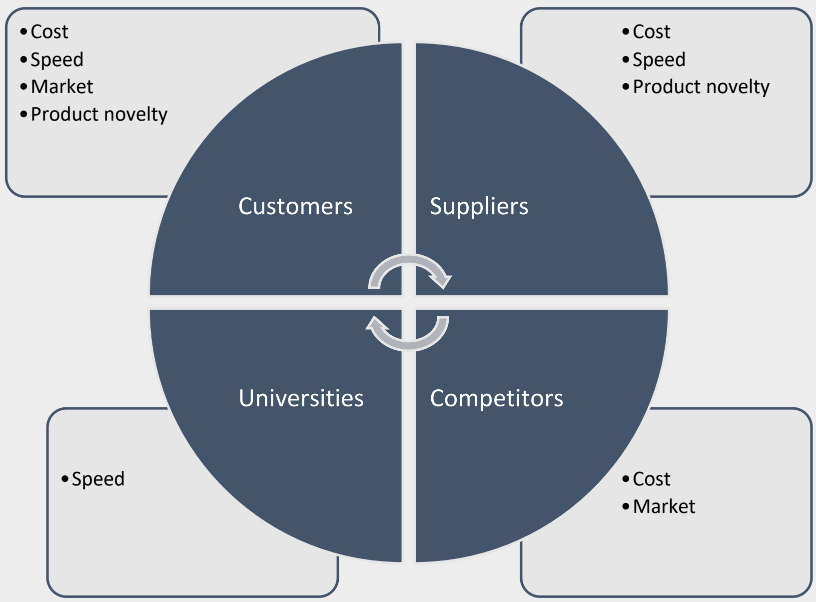
- **Intra-organizational complexity and lack in Exploration capacity**
- **Environmental and Intra-organizational complexities and lack in Exploration and Exploitation capacities**.

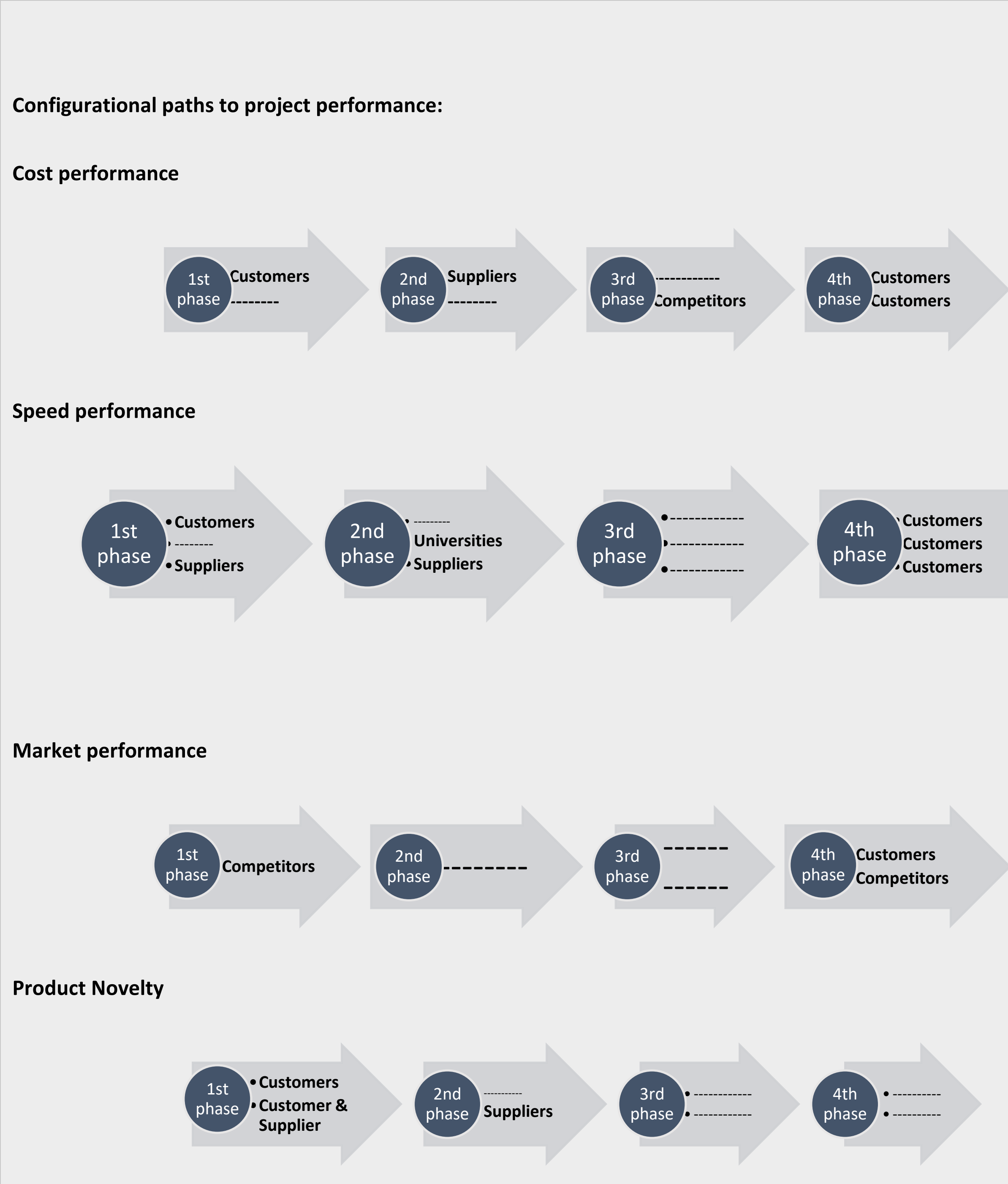
5.1.3- Conclusions chapter 4

The most important conclusion of this study is that the impacts of knowledge source involvement in new product development projects and its impact on project performance is more complicated than just “more is better” conclusion identified in literature review previously. Also, effects of collaboration on performance is related to which source of knowledge, at what development process stage is involved. Using integrated product development teams and concurrent process of product development are considered as two important NPD paradigms during past twenty years. Still their effect on NPD performance is not identified properly. Most of the previous studies are case-based and conceptual. There are few incomplete studies which empirically investigated these practices because their main focus was on speed of product development. But, speed is considered as one of many NPD success determinants. Thus, previous studies are yet inconclusive, with some contradictory results (Gerwin and Barrowman, 2002). This research is aimed to fulfill this gap in previous studies. This research has many contributions to previous studies conducted on NPD and open innovation. Unlike past studies which only concentrated on just one NPD performance dimension such as cost or time, this research employed multidimensional performance evaluation, so offers a better idea of external collaboration impacts and involvement of various knowledge sources in projects. There was no negative effect of knowledge source involvement on NPD performance as previously noted in literature. Also, this study revealed that there is a positive and significant relationship between NPD performance dimensions and external collaboration. Finally, this research empirically examined involvement of various knowledge sources in NPD project phases instead of analyzing involvement of these sources of knowledge in project levels of the firm.

Table 13- Summary of conclusions of chapter 4

Chapter 4
Objective: In this chapter we want to see if involving different knowledge sources in NPD process will have effect on project performance.
Conclusions: The results show that various configurations of involving knowledge sources in different phases of NPD process will result of different dimensions of project performance (Cost, Speed, Market and product novelty). As we can see in below, customers can contribute in all dimensions of project performance and collaboration with the universities can improve the speed of the projects. Suppliers can provide necessary knowledge to improve cost, speed and product novelty and competitors can improve the cost and market performance of our projects. But as we can see in results, these improvements in performance will achieve if we can involve different knowledge sources in right time of the innovation process.





Configurational paths to project performance:
Cost performance
1st phase
Customers

2nd phase
Suppliers

3rd phase

Competitors
4th phase
Customers
Customers
Speed performance
1st phase
• Customers
• --------
• Suppliers
2nd phase
• --------
Universities
• Suppliers
3rd phase
• ------------
• ------------
• ------------
4th phase
• Customers
Customers
• Customers
Market performance
1st phase
Competitors
2nd phase

3rd phase

4th phase
Customers
Competitors
Product Novelty
1st phase
• Customers
• Customer & Supplier
2nd phase

Suppliers
3rd phase
• ------------
• ------------
4th phase
• ----------
• ----------

5.1.4- General conclusions

The results of this study provide theoretical contributions to the literature and offer practical implications for low-technology SMEs, simultaneously taking into account both management open innovation and new product development. This research is distinctive because it presents research, which is informed by the theoretical understanding of three theoretical viewpoints (knowledge-based view, resource based view and configurational theory). I believe that this examination of SME's of new product development in the context of open innovation framework enhances the existing literature in several important ways.

1. This study contributes to the complexity view and open innovation literature in three important ways.

   a) First, in exploring four types of complexity in NPD projects and the role of these complexities in open innovation development, this research introduces a new conceptual model for future studies.

   b) Second, differentiating between four phases of NPD projects in developing open innovation practices (idea generation, design, production and commercialization) and arguing that project complexity can have direct effects on strategic decisions to implementing different practices of OI in each phase of NPD projects (Sihvonen & Pajunen 2019; Felin & Zenger, 2014).

   c) Third, making an initial effort to distinguish empirically between implementation of OIP in different phases of NPD projects.

2. This research makes an important theoretical contribution by describing supporting arguments in the open innovation literature. this study makes a contribution to the literature by confirming that SME's will develop partnership as a solution to solve complex innovation problems in their innovation process (Felin & Zenger, 2014). Also, the findings show that the implementation of partnership strategy in new product development process is varying between different companies and they make the partnership in different phases of the process. The possible explanations for these findings are that each of the companies has different level of absorptive capacity and settings for knowledge resources.

3. This research contributes to the literature on open innovation by taking an empirical look at how knowledge resources are involving in innovation process and its performance when it implements open innovation practices. The research uses a more conceptual approach than many previous studies, highlighting the knowledge-based view that is new to empirical open innovation literature and data that includes SMEs. This research clearly established that involving the four types of knowledge resources: Suppliers, Customers, Universities and competitors in innovation process, have a direct influence on different dimensions of project performance. In fact, these findings relate to the existing literature to support all the claims regarding negative impact of knowledge source involvement on project performance (Laursen, 2011; Faems et al., 2005; Lau et al., 2010; Nieto and Santamaria, 2007; Un et al., 2010). The possible explanations for these findings are the importance of configurational paths on involving different types of knowledge sources in each phase of NPD process.

4. open innovation and project performance literature: The relationship between open innovation and project performance was based on the types of knowledge resources involved in project level (Bahemia and Squire, 2010; Tranekjer and Sondergaard, 2013). Therefore, this research can hopefully create more awareness of business excellence, encourage strong leadership, and increase levels of strategic creativity, by providing more evidence on how different configurations of KS involvement in different phases of NPD process, can contribute to the different dimensions of project performance.

5. This research focuses on innovation in the project phase level by considering four phases in NPD projects (idea generation, design, production and commercialization). A model is proposed as a result with the unique effect of creating mediator roles for strategic decision making with regard to open innovation practices and involving knowledge resources towards project performance. The existing innovation literature only considers the development of one form of project performance, without making a link to configurational path of KS involvement in different phases of NPD projects. innovation and business performance (Bahemia and Squire, 2010; Bonesso et al., 2011). To assess the effect of open innovation and external collaboration on project performance, both practitioners and researchers need to measure a broad set of performance variables - including cost, market, speed and product novelty (Zhao et al 2015). As the results of this research show, the relationships between involving knowledge resources, open innovation practices, project

complexity, and project performance are complex. The complementarities of innovation such as open innovation and successful new product development suggest that future mapping will need to pay much more attention to the improved models to involve knowledge resources and implementation of OIP in new product development process.

5.2- Managerial Implications

The findings of this thesis suggest one means of moving beyond what Bogers et al (2018) named as the intersection of research, practice, and policy and the importance on transforming the trend of research in open innovation, from pure theoretical research to the practical ones.

In this thesis we developed different configurational strategies for the implementation of OIP and involving different knowledge sources in NPD process. We used project phase as the unit of analysis to provide more evidence on implementation of OIP and KS insolvent in each phase of NPD projects. We showed that how companies can reduce the level of project complexities in each phase of NPD projects by implementing partnership with different knowledge sources. We showed that how the companies have to combine different KS in our NPD projects to achieve different dimensions of the project performance and clarified that mixing different knowledge sources in NPD projects can result to positive performance.

We developed an integrate framework of project complexity for the companies to be able to use it in their pre-assessment of their project performance and define better strategies in their open innovation implementation.

We provided evidence on how the companies can improve the level of internal capabilities in order to achieve necessary knowledge for their innovation process.

5.3- Limitations and avenues for future research

Every effort was made at the design stage of this thesis to obtain reliable and valid findings, as presented in the research methodology in each chapter. Nevertheless, one significant limitation of this study should be discussed.

This research indicates the contribution in open innovation and innovation management fields with respect to the role of project complexity, absorptive capacity, knowledge resources, management innovation, project phases and project performance. There are gaps in the current research that may create opportunities for the future research.

1. In terms of contextual aspects, this research only included small and medium size companies and the sample data was from Spain. This study was only restricted to low technology intensive companies. Future research could be carried out by testing this model in more countries, in high technology companies and also in big companies.

2. This research relies on survey data only. As far as construct validity is concerned, the use of self-reported data constitutes a major limitation. The size of this study's sample, with the limited time and resources it used, made it difficult to employ another method. Also, the major problem when investigating performance at the project level is the difficulty of obtaining objective performance measures. The firms included in this sample are at various stages of technological development. To overcome this, future research should consider using longitudinal data to show how innovation management and OIP takes place and accumulates over time. With multi-time data, it would be possible to address such questions as "How does external collaboration and involving KS actually develop over time?" and "Do firms acquire external knowledge in different processes sequentially?"

3. The methods chosen for this research were only limited to personal interviews. Further research should test the proposed framework by using different methodologies such as survey questionnaires to be able to expand the number of sample and geographical area.

4. The current research was only focused on absorptive capacity as the representative of internal capabilities and the findings may only relate to these types of innovation. Future research could be conducted into different types of internal capabilities such as technological, organizational and so on.

5. The measures of project performance are based on the manager's perceptions. Future research should obtain objective measures such as profit, return on sales, return on profits and patents

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Appendix

Appendix 1- Final ACAP scale

Exploration

Please specify to what extent your company uses external resources to obtain information (e.g., personal networks, consultants, seminars, internet, database, professional journals, academic publications, market research, regulations, and laws concerning environment/technique/health/security):

Exploration 1- The search for relevant information concerning our industry is every-day business in our company.

Exploration 2- Our management motivates the employees to use information sources within our industry.

Exploration 3- Our management expects that the employees deal with information beyond our industry.

Exploration 4- We observe in detail external sources of new technologies

<u>(5-point scale, where 1 = strongly disagree and 5= strongly agree)</u>

Assimilation

Please rate to what extent the following statements fit the communication structure in your company:

Assimilate 1- In our company ideas and concepts are communicated cross-departmental.

Assimilate 2- Our management emphasizes cross-departmental support to solve problems.

Assimilate 3- In our company there is a quick information flow, e.g., if a business unit obtains important information it communicates this information promptly to all other business units or departments.

Assimilate 4- Our management demands periodical cross-departmental meetings to interchange new developments, problems, and achievements.

(5-point scale, where 1 = strongly disagree and 5= strongly agree)

Transformation

Please specify to what extent the following statements fit the knowledge processing in your company:

Transform 1- Our employees have the ability to structure and to use collected knowledge.

Transform 2- Our employees are used to absorb new knowledge as well as to prepare it for further purposes and to make it available.

Transform 3- Our employees successfully link existing knowledge with new insights.

Transform 4- Our employees are able to apply new knowledge in their practical work.

Transform 5- When recognizing a business opportunity, our employees quickly rely on existing knowledge.

(5-point scale, where 1 = strongly disagree and 5= strongly agree)

Exploitation

Please specify to what extent the following statements fit the commercial exploitation of new knowledge in your company (NB: Please think about all company divisions such as R&D, production, marketing, and accounting):

Exploit 1- Our management supports the development of prototypes.

Exploit 2- Our Company regularly reconsiders technologies and adapts them accordant to new knowledge.

Exploit 3- Our Company has the ability to work more effective by adopting new technologies.

(5-point scale, where 1 = strongly disagree and 5= strongly agree)

- ✓ **Acquisition** refers to a firm's ability to identify and obtain knowledge from external sources (e.g., suppliers). (Zahra & George, 2002)
- ✓ **Assimilation** refers to a firm's ability to develop processes and routines useful in analysing, interpreting, and understanding externally acquired knowledge (Szulanski, 1996).
- ✓ **Transformation** means developing and refining those routines that facilitate combining existing knowledge with acquired and assimilated knowledge for future use (Zahra & George, 2002).
- ✓ **Exploitation** denotes a firm's capacity to improve, expand, and use its existing routines, competencies, and technologies to create something new based on the ''transformed'' knowledge. (Zahra & George, 2002)

Appendix 2- Total TOEI framework and Project complexity measurement scales <u>(5-point scale, where 1 = very low and 5= very high)</u>

TOEI	Sub-ordering	Elements defined	Explanation	Appropriate external collaborator	OIP
T	Goals	Number of goals	The number of strategic project goals?	Clients	Partnership
T	Goals	Goal alignment	Are the project goals aligned?	Clients	Partnership
T	Goals	Clarity of goals	Are the project goals clear amongst the project team?	--------------	--------------
T	Scope	Uncertainties in scope	Are there uncertainties in the scope?	Clients	Partnership, Seller/Buyer
T	Scope	Quality requirements	Are there strict quality requirements regarding the project deliverables?	Suppliers, Clients	Community, Seller/Buyer
T	Tasks	Number of tasks	The number of tasks involved?	Universities, Suppliers	Platform, Partnership
T	Tasks	Variety of tasks	Does the project have a variety of tasks (e.g. different types of tasks)?	Universities, Suppliers	Platform, Partnership
T	Tasks	Dependencies between tasks	The number and nature of dependencies between the tasks?	Universities, Suppliers	Partnership
T	Tasks	Uncertainty in methods	Are there uncertainties in the technical methods to be applied?	Universities, Suppliers	Platform, Partnership
T	Tasks	Conflicting norms and standards	Are there conflicting design standards and country specific norms involved in the project?	Suppliers, Clients	Platform, Partnership

T	Experience	Newness of product (world-wide)	Did the project end-up with new product (product which is new in the world, not only new to the company!)?	Suppliers, Clients	Partnership, Seller/Buyer
T	Experience	Experience with new product	Do the involved parties have experience with the new products developed?	Suppliers, Clients	Community, partnership, platform
O	Size	Project duration	What is the planned duration of the project?	Suppliers, Experts	Partnership, platform
O	Size	Size in Engineering hours	What is the (expected) amount of engineering hours in the project?	Suppliers, Experts	Partnership, platform
O	Size	Number of locations	How many locations are involved in the project, including different local or international markets?	Competitors, Clients	Partnership, seller/buyer
O	Resources	Project drive	Is there strong project drive (cost, quality, schedule)?	Suppliers	Partnership
O	Resources	Resource and skills availability	Are the resources and skills which are necessary, exist in the project?	Suppliers	Partnership
O	Resources	Experience with parties involved	Do you have experience with the parties involved in the project?	---------------	Partnership
O	Resources	Number of financial resources	Is there any financial resources which the project need to have?	Suppliers (VC, BA)	Partnership
O	Project team	Number of different nationalities	What is the number of different nationalities involved in the project team?	Suppliers, Clients	Partnership
E	Location	Interference with existing production site	Do you expect interference with the current production site?	Competitors	Partnership

E	Location	Business regulation	Do you expect unstable and/or any restrictions in the target market?	Suppliers, Clients	Partnership, Seller/Buyer
E	Location	Local or international project	The project will take place in international markets?	Clients, Competitors	Partnership
E	Location	Experience in the country	Do you have previous experience in that market?	Clients, Competitors	Partnership
E	Market conditions	Market Stability	Is the project environment stable (e.g. exchange rates, raw material pricing)?	Suppliers, Clients	Partnership, Seller/Buyer
E	Market conditions	Market competitiveness	What is the level of competition (e.g. related to market conditions)?	Clients, Competitors	Partnership, Seller/Buyer
I	Locus of Control	IP Protection	Are there any regulations for IP protection in the target market?	Clients	Partnership
I	Formality	Formalization	To what extent the communications with the partner has to be based on Standards, protocols and procedures?	-------------------	Partnership
I	Information and resource Flow	Inbound, Outbound or couple	Do you expect to send and receive resources and information from your partner?	Suppliers, Clients, Universities	Partnership, Seller/Buyer

Appendix 3- Project performance measurement scales

(5-point scale, where 1 = very low and 5= very high)

(Ranekjer and Sondergaard, 2013)

Cost
1 Cost compared to industry standard
2 Cost compared to expectations
3 Cost compared to typical NPD project in firm
Speed
1 Speed compared to what is usual in industry
2 Speed compared to expectations
3 Speed compared to typical NPD project in firm
Market performance
1 Growth in product category sales?
2 Revenue?
3 Profits?
Product novelty
1 Product was innovative- first of its kind
2 Considered by customers as being a better product compared to products of competitors

Appendix 4- First paper

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Research paper

Complexity as an Antecedent for External Collaboration in New Product Development Projects

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Abstract

This study examines how project complexity in low technology-intensive small- and medium-sized enterprises (SMEs) contribute in implementation of open innovation practices, during their new product development projects. The main focus of this paper is to investigate the critical role of complexity in the project level to identifying the compatibility of those external sources involved in NPD. The low technology-intensive sector in Spain were chosen as a target context, there were many innovative SMEs operating in these industries and because these sectors were going through significant changes. Four external knowledge sources, Universities, suppliers, customers and competitors and four open innovation practices, Community, Platform, Partnership and seller-buyer agreement, in the new product development were identified. The study shows that in SMEs, project complexity plays an important role in selecting the external source and implementation of open innovation practices. The main conclusion of the study is that the external collaboration in new product development projects is detemined by different dimensions of project complexities and in projects with different type of complexity, the SMEs follow different external knowledge sources and open innovation practices. The study results imply that SMEs benefit from opening up their innovation process in the new product development projects. The firms in this study employed a blend of strategies that is more compatible with dimensions of project complexity. They collaborated actively with different external knowledge source and different modes of collaboration, when they have determination of different dimensions of project complexity. Also, the study extends understanding of the strategic use of open innovation in SMEs by demonstrating how SMEs balance the risk of project complexity built on new product development and the benefit of creating a wider capability base with partnerships.

Keywords: *SME, New product development, Open innovation practices, Collaboration strategies, Collabonation modes.*

1. Introduction

New product development (NPD) refers to a focal point in competition that leads to many advantages, including higher product quality and a shorter time to market. Organizations are able to reach markets faster and more efficiently and might succeed in generating a sustainable competitive advantage that is not easy for their rivals to imitate. Therefore, NPD results not just in access to new markets but also in improvements to the competitiveness of companies and facilitates relationships with other firms (Veliyath et al., 2000). One of the main issues is the necessity to mobilize not only internal resources but also external actors in new product development. Thus, the process of development entails a series of actions that cut across many different functions, both external and internal, of an organization, and an increase in product performance and technological complexity will build relationships with important suppliers to contribute to the success of any organization. Regarding the advantages of integrating external innovation sources into the NPD process, many companies utilize a Japanese-style policy for their suppliers. When they become responsible for designing the whole system as well as subassemblies, they are integrated systematically into the design and production process of the organization (Bell, 1999; Chesbrough et al., 2006; Karmarkar, 2004; Schulttze and Stabell, 2004; Tidd and Hull, 2003). Therefore, the innovative bonds among a lead manufacturer and the nearby group of external suppliers play a key role in generating flexibility, and they are assumed to be the main key to better products as well as a shorter development cycle (Ireland et al., 2002).

Collaborating not just with suppliers but generally with any external sources is accepted to increase organizational learning (Inkpen and Tsang, 2005; Powell et al., 1996), and, because new knowledge is usually retrieved from outside an organization, interorganizational relationships are critical (March, 1991). This is the same idea as that put forward in previous studies on open innovation, in which inbound open innovation was considered to be an important factor for innovation (Chesbrough, 2003). Open innovation has been described as the use of purposive outflows and inflows of knowledge to improve internal innovation and to expand the markets for using innovation externally (Chesbrough, 2003; Van de Vrande et al 2013). A great deal of attention has been paid to open innovation during the past years (Chesbrough et al., 2006; Elmquist et al 2009; West and Bogers, 2014; West et al 2014). Open innovation researchers have emphasized the need for focal firms to transcend their boundaries through external technology and knowledge sourcing. The current study discusses innovation complexity, environmental uncertainty and knowledge recombination as resulting in enhanced permeability of the boundaries in an organization and the need for them to interact more openly with external stakeholders and the environment (Karl-Heinz, 2015). The idea of open innovation includes a broad range of external factors, such as users, suppliers, customers, competitors and universities. The underlying mechanism to achieve external

Appendix 5- Second paper

Supply Chain Management Strategies in Project and Absorptive Capacity to Implementation Partnership Strategy in New Product Development

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***Abstract*—To develop new and successful products, supply chain management can be efficient way as a multidisciplinary process. It appears logical to consider that some elements, such as fast changes in technology, a flexible process of production, and international rivalry, have a direct relationship across various knowledge sources and are more necessary for introducing timely and profitable new products. Our main emphasis is to make a comparative assessment for the role of decomposed attributes of complexity level in new project development (NPD) and internal abilities to choose partnership as dominant mode for external collaboration in different phases of NPD, by using supply chain management design across 125 NPD projects in low technology-intensive SMEs in Spain. The results provide support for the role of absorptive capacity and different dimensions of project complexity in developing a co-development strategy (Partnership) in different phases of NPD projects.**

Keywords*—*Open innovation, supply cahin management, absorptive capacity, project complexity, co-development, fsQCA, new project development

1. Introduction

Practitioners and academics agree that innovation is one of the necessary factors to thrive in a global dynamic economy. Supply chain management (SCM) and innovation provide only a certain level of adaptation to the fast and disruptive modifications in economic, technological, social, and regulatory contexts of organisations; however, they provide a tool to drive and form such changes as well as other benefits, including higher-quality products and decreased time to market. Hence, they not only offer a critical competitive advantage and key factor of growth and wealth of organisations[1] but also help to improve facilities and the flexibility of relationships with other companies [2].

To develop new and successful products is a multidisciplinary process. It appears logical to consider that some elements, such as fast changes in technology, a flexible process of production, and international rivalry, have a direct impact across various companies and are more necessary for introducing timely and profitable new products. In addition, companies have coordination mechanisms, such as quality functional deployment procedures; organisational structures, such as cross-functional teams, and capabilities, such as absorptive capacity, in order to improve their functional interaction level and knowledge integration during NPD[3-7].

Many studies seem to show positive impacts of knowledge source integration in NPD and innovation success in many cultural environments [8-12]. Therefore, we can conclude that organisations experience new methods that include more external factors and support exchange of information and collaboration in different contexts. Moreover, participating in open innovation involves ambiguity and uncertainty [13, 14] for an overview, see [15-20].

The level and type of knowledge sharing and information exchange are different in open innovation stages and procedures, because innovation issues are varied due to the complexity level [2, 21]. Complex issues include a variety of interdependent factors, knowledge, and choices that should be addressed creatively in order to generate useful solutions [22]. This complicates conditions

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