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

Reza Gheshmi [1], Hugo Zarco [2], Frederic Marimon [3]

[1,3]*Universitat Internacional de Catalunya*
[#]*School of Business and Engineering- La Salle University*

***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

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 [23].

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 NPDprocess. 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 recognized, 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 [15,16]. The traditional industries that are known generally by the presence of SMEs show little R&D intensity or innovation capacity [1], so their absorptive capacity usually is operationalised as the intensity or existence of R&D facilities of a company [24]. Zahra and George 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 organization [25]. 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[26, 27].

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 [28].

To solve complicated issues, a company needs to have a level of knowledge or theory of interaction patterns between relevant knowledge and choices [29]. 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 [4]. 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 [2]. The governance mode we choose in external collaboration will be different with the change in the level of project complexity [6]. 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 [15]. Alliances, partnerships, and corporate venture capital (CVC)

involve a set of governance types that help solve issues of high or intermediate complexity [30]. Different governance modeare 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 [11]

We emphasize that investigating the SCM 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 [6, 9]. Previous studies have focused on different types of sources and combinations at the project level [7].

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, who proposed a conceptual framework that includes three dimensions of inbound openness: ambidexterity, depth, and breadth [6].

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 [14]. The theory is rooted in previous studies [17] 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 [8]. The stronger the fit between structure and strategy is, the better the performance [9]. Meyer et al. (1993) explain organisational configurations as any kind of multidimensional constellation of conceptually distinct characteristics which take place together [15]. 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 [17]. In addition, a proper set of variables or conditions will not usually result in better performance [23].

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 [21]. Therefore, there are many methods for success. Meyer et al. noted [16]:

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’[14] and also are almost in nature long lasting [13], 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. SCM through fsQCA

Set-based methods like Fuzzy Set Qualitative Comparative Analysis (fsQCA) involve proper tools to provide nonlinear relationships and complementarities between constructs [20]. 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 memberships. 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[19]. This analysis joins parsimony and complexity together through integration of many causal relationships into a few typified profiles [11]. Moreover, fsQCA facilitates to make difference between sufficient and necessary causal condition to implement co-development as the dominant mode for external collaborations [11]. 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 [12], 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

4.1Data 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. A series of in-depth interviews with firms were conducted individually (R&D directors and CEOs), in line with the process outlined by [25]. 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. 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, we employed a multiple case design, which included 125 NPD projects from 85 manufacturing companies across eight industries in Spain [26]. Following [5], replication logic was used for case selection. This information-oriented method was chosen to improve information utility from single cases and small samples [3].

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 [1].

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 [26]. 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 [26].

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 1 presents potential constructs and measurement techniques.

Table 1. Potential constructs for developing co-development in the NPD process

Variable	Type	Measurement method	Description
Co-development [5].	Binary	= 1 if the company applied co-development 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 Zschoch, 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 [9]. All insignificant items or items with less than 0.5 loadings were omitted from the measurement model. The guidelines provided by [5] 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 [17]. 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 [6], and the composite reliability should be more than 0.7 [3] for all the variables in this study. According to the results presented in Table 2, the reliability and dimensionality of all variables were acceptable.

Table 2. 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 [6]. 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 [5] The interval scale factors were converted into fuzzy set membership scores by means of the fsQCA software calibrating function [6] in line with the process detailed by [8]. To calibrate factors, the experts defined values of interval scale factors corresponding to three main qualitative anchors to structure the fuzzy set [6]: 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 [7]. In order to specify such qualitative anchors, we provide a rationale for each breakpoint [5]. 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 3) of 5.0, 1.0, and 3.0 corresponding to full membership, full non-membership, and cross-over anchors, respectively.

Table 3. 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 [6]. In addition, relationship performance is reachable if the condition in question (co-development) takes place [12]. Thus, consistency scores were scrutinized; they can measure the level to which observations are in line with this specific rule [9]. The more that observations fail to fulfil the rule for critical conditions, the consistency score will be lower as well [5]. A single condition could be assumed as important if the corresponding consistency score is more than the threshold equal to 0.9 [8]. 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 notes that gaps in high consistency values are helpful to generate a consistency threshold, and those less than 0.75 demonstrate substantial inconsistencies [7]. 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 [4]; as a result, these solutions were selected in this research. Table 4 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, Table 4 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 [17]. 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 organisational 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-organisational complexity as well as the absence of organisational 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-organisational 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 4 provides a summary of intermediate solutions, with co-development strategy implementation as the result in the second stage (design) of NPD projects.

Table 4. Intermediate solutions with partnership in different stages of NPD as a causal outcome

	Idea Generation (1st Phase)		Design (2nd Phase)		Production (3rd Phase)		Commercialization (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 organisation 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 4also 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 NPDprojects. In configuration 1, excluding technical complexity, inter-organisational, 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, organisational complexity is not a critical variable, and in these same configurations, limited transformation and exploration capacities as well as inter-organisational complexity are the most effective variables to force firms to apply co-development strategy in the third stage of NPD projects.

Table 4summarises intermediate solutions considering co-development strategy as the result of the last stage (commercialisation) of NPDprojects. The table also shows that the consistency value are more than 0.9, demonstrating that such configurations have enough conditions for co-development strategy implementation in the fourth stage of NPDprojects. 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 NPDprojects. Configuration 1 reveals that environmental complexity should be present with the inter-organisational complexity and no exploitation and exploration capabilities to implement a co-development strategy in this stage of an NPDproject. 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-organisational complexity in the commercialisation stage of NPDprojects. Finally, regarding configuration 5, with maximum raw consistency and optimum coverage, it can be seen that environmental and inter-organisational 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 of SCM can suggest some resources and ideas that aid companies in achieving and understanding innovative opportunities [15]. 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 [12]. 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 [8]. 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 [8]. Current research providemore knowledge on the above-mentioned conflicting point of view,with presenting the project complexity as the antecedent to develop external collaboration [3] 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 [2]. Hence, it can be more helpful for companies to retain good relationships with a few collaborators to determine what knowledge to keep and this 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 [4].

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 [3]. 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 [4] 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 [4]. 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[3].

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 analysing 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 organisational and individual variables [3].

7. Conclusion

This research examined the role of project complexity and absorptive capacity in implementation of co-development SCM 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 co-development 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 organisations. 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-organisational complexities on SCM. In order to solve them, they should improve their exploitation and exploration capabilities.

References

[1] Von Tunzelmann N, Acha V. Innovation in “low-tech” industries. InThe Oxford handbook of innovation 2005.

[2] Ancona, Deborah Gladstein, and David F. Caldwell. "*Demography and design: Predictors of new product team performance*." Organization science 3, no. 3, 321-341, 1992.

[3] Ahuja, Gautam, and RiittaKatila. "*Technological acquisitions and the innovation performance of acquiring firms: A longitudinal study*." Strategic management journal 22, no. 3, 197-220, 2001.

[4] Argote, Linda, Bill McEvily, and Ray Reagans. "*Managing knowledge in organizations: An integrative framework and review of emerging themes*." Management science 49, no. 4, 571-582, 2003.

[5] Bagherzadeh, Mehdi, and Sabine Brunswicker. "*Governance of Knowledge Flows in Open Innovation through Revealing and Behavioral Control*." In Academy of Management Proceedings, vol. 2015, no. 1, p. 17565. Briarcliff Manor, NY 10510: Academy of Management, 2015.

[6] Bahemia, Hanna, and Brian Squire. "*A contingent perspective of open innovation in new product development projects*." International Journal of Innovation Management 14, no. 04, 603-627, 2010.

[7] Battisti, Giuliana, and Paul Stoneman. "*How innovative are UK firms? Evidence from the fourth UK community innovation survey on*

synergies between technological and organizational innovations." British Journal of Management 21, no. 1, 187-206, 2010.

[8] Birkinshaw, Julian, Gary Hamel, and Michael J. Mol. "*Management innovation*." Academy of management Review 33, no. 4, 825-845, 2008.

[9] Bonesso, Sara, Anna Comacchio, and Claudio Pizzi. "*Technology sourcing decisions in exploratory projects*." Technovation 31, no. 10-11, 573-585, 2011.

[10] Camisón, César, and Ana Villar-López. *"Non-technical innovation: organizational memory and learning capabilities as antecedent factors with effects on sustained competitive advantage*." Industrial Marketing Management 40, no. 8, 1294-1304, 2011.

[11] Cassiman, Bruno, and ReinhildeVeugelers. "*In search of complementarity in innovation strategy: Internal R&D and external knowledge acquisition*." Management science 52, no. 1, 68-82, 2006.

[12] Cheng, Colin C., and Dennis Krumwiede. "*The role of service innovation in the market orientation—new service performance linkage*." Technovation 32, no. 7-8, 487-497, 2012.

[13] Cheng, Cheng-Feng, Man-Ling Chang, and Chu-Shiu Li. "*Configural paths to successful product innovation*." Journal of Business Research 66, no. 12. 2561-2573, 2013.

[14] Chesbrough, Henry. *Open business models: How to thrive in the new innovation landscape*. Harvard Business Press, 2006.

[15] Chesbrough, H. "Open innovation, Boston, MA: Harvard Business School Press." *Translation by Keiichiro Omae [2004],"Open Innovation"* SANNO Institute of Management Publication Dept (2003).

[16] Chesbrough, Henry W. "*The Era of Open Manufacturing.*" Sloan Management Review 44, no. 3, 35-41, 2003.

[17] Chin, Wynne W. "*How to write up and report PLS analyses.*" In Handbook of partial least squares, pp. 655-690. Springer, Berlin, Heidelberg, 2010.

[18] Daft, Richard L., and Robert H. Lengel. "*Organizational information requirements, media richness and structural design*." Management science 32, no. 5, 554-571, 1986.

[19] Dahlander, Linus, and David M. Gann. "*How open is innovation?.*" Research policy 39, no. 6, 699-709, 2010.

[20] Damanpour, Fariborz, and DeepaAravind. "*Managerial innovation: Conceptions, processes and antecedents*." Management and organization review 8, no. 2, 423-454, 2012.

[21] Damanpour, Fariborz, Richard M. Walker, and Claudia N. Avellaneda. "*Combinative effects of innovation types and organizational performance: A longitudinal study of service organizations*." Journal of management studies 46, no. 4, 650-675,2009.

[22] Doty, D. Harold, and William H. Glick. "*Typologies as a unique form of theory building: Toward improved understanding and modeling*." Academy of management review 19, no. 2, 230-251, 1994.

[23] Doty, D. Harold, William H. Glick, and George P. Huber. *"Fit, equifinality, and organizational effectiveness: A test of two configurational theories.*" Academy of Management journal 36, no. 6, 1196-1250, 1993.

[24] Dyer, Jeffrey H. "*Effective interim collaboration: how firms minimize transaction costs and maximise transaction value*." Strategic management journal 18, no. 7, 535-556, 1997.

[25] Eisenhardt, Kathleen M., and Melissa E. Graebner. "*Theory building from cases: Opportunities and challenges*." The Academy of Management Journal 50, no. 1, 25-32, 2007.

[26] Eisenhardt, Kathleen M. "*Building theories from case study research*." Academy of management review 14, no. 4, 532-550, 1989.

[27] Ettlie, John E., and Paul A. Pavlou. "*Technology‐based new product development partnerships*." Decision Sciences 37, no. 2, 117-147, 2006.

[28] Ettlie, John E. "*Integrated design and new product success*." Journal of operations management 15, no. 1, 33-55, 1997.

[29] Evangelista, Rinaldo, and Antonio Vezzani. "*The economic impact of technological and organizational innovations. A firm-level analysis*." Research Policy 39, no. 10, 1253-1263, 2010.