Configurational Path to NPD Project Performance- Involving Source of Innovation in Supply Chain Strategy

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***Abstract*— During past twenty years, knowledge integration and product development process, have been considered as two critical strategies for new product development process. The two mentioned strategies were the main focus of industry and also academicians as well as many practitioners). The most significant similarity among the investigations on this integration strategy is the focus on organizations as unit of analysis and in some cases, the investigations was in project level in order to have more accurate and detail results. But in this study we considered project phase and the unit of analysis to be able to take into account the project and different phase's characteristics. In this way we will be able to find more relevant and practical results for integration different source of knowledge, in different phases of new product development. We analysed 125 new product development projects from total 85 manufacturing firms, which have implemented at least one form of external collaboration among their NPD projects, within 8 different industries in Spain. To make these analysis we used fsQCA method and our finding show that by involving different types of knowledge sources in different phase of NPD projects, the companies may achieved to different level of Cost, Market, Speed and product Novelty performance and these configurations are very between different projects.**

***Keywords*—** *Open innovation, new product development (NPD), supply chain strategy, Cost performance, Market performance, Speed performance and product novelty performance.*

1. Introduction

The necessity to support innovation through contribution with external sources of knowledge, for example customers or providers, is not a new topic [1-5]. During past twenty years, knowledge integration and product development process, have been considered as two critical strategies for new product development process [6]. The two mentioned strategies were the main focus of industry and also academicians [7-10] as well as many practitioners. Recently, emphasize on open innovation has been changed. 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 [11]. In current study, we emphasize on knowledge's inbound flow from external resources. Most of the studies on collaborative innovation and external collaboration have considered understanding the efficient amount of external partners [12], as well as critical role of various external sources [13-20]. The most significant similarity among these investigations is that the studies have been performed at organizational level which means collaborating and searching are considered as a total organization decision rather than a decision according to requirements of particular NPD projects. According to our knowledge, there are few studies on impacts of including various external resources at NPD projects level within open innovation context. The main premise of this research is that both relationships with external knowledge resources and combination of many relationships in all NPD phases are critical for new product development performance. Researchers have noted that practices of product development need to be dependent on complexities and features of projects. Each single phase of new product development projects has unique features which 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 main objective of this research will be investigating external collaboration at project phase level for contributing to previous studies on open innovation with more detailed and comprehensive view of existed 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 accurate and varied picture of innovative

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functions in organizations and also their impacts while compared to conducted studies on project or organization level .Due to new product development projects can be assessed on different aspects,
we have added related performance measures to market performance, speed and cots. The key goal is to offer a better comprehensive view on relationship between combinations of external knowledge sources and project phase level performance.
This article will continue by discussing previous studies which support research gaps and also hypotheses development in Section 2; then in Section 3, variables and methods will be presented, descriptive results and findings achieved by ordinary least square regression will be presented in Section 4 and finally further conclusions and discussions are defined.

Review of Relevant Literature

Previous studies on open innovation and inter-organisational innovation demonstrate that contribution of external sources is a key approach to access useful knowledge sources for innovation [21]. The most important benefit achieved from previous studies is having access to external knowledge sources and chance of learning from partners via knowledge transfer [22]. However, risk and cost sharing are necessary motivational elements to participate in external partners relationships. A study of previous investigations on innovation and external sources at project phase level revealed two gaps which will be presented in this article:

1- Combination of sources rather than isolated sources
2- Collaboration with various knowledge sources in NPD phases

For analysis level, there are few studies done about impacts of external sources at project level. Primarily, project level has been utilized in studies on contribution of one particular partner, such as involvement of provider in industrial marketing studies/supply chain management [23] and regarding studies on customer contribution in market [24] as well as lead users. But, in case of more common impacts of external sources on new product development projects, there are rare results. For combining various external sources, usually sources are studied in larger dimensions means that many external sources are involved and for individual impact [16], although previous studies show the key role of combining various sources. The question is that if using a mixture of different sources is better compared to using similar types of a single source or not. Also if various phases of project are crucial elements in mixing of sources.

Configuration theory and analyses

Configuration theory

The configuration theory is a technique to understand how organizational structure have relationship with strategic intent. This theory was initiated in literature and explains that for any particular context, specific organizational configurations of structure and strategy can fit efficiently compared to other configurations which lead to improved performance. If the fit between strategy and structure is strong enough so the performance improves too.

Operationalizing configuration theory through fsQCA

The set-based techniques such as Fuzzy Set Qualitative Comparative Analysis (fsQCA) include appropriate tools for providing complementarities and nonlinear relationships between different constructs. Instead of disaggregating a variety of cases into many independent variables, this analysis is able to conceptualize factors as combinations of different manifested attributes by a group of memberships. fsQCA offers knowledge about how various cases combine together for developing a particular result which generates huge casual complexity level and describes critical and efficient conditions based on configurational results. To perform 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.

2. Methods and materials

Data sources

Spanish organizations with limited knowledge intensive and one NPD project at least, in a variety of industries during last two years, are assumed as the sample population of the study. Both primary and secondary data sources were gathered and data construct validity confirmed according to triangulation rules. These interviews have been performed to emphasize on NPD projects and different kinds of external collaboration (with concentration on frameworks of open innovation), and also organization’s absorptive analysis through semi-structured questions and face-to-face interviews. These interviews have been 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 have been transcribed and recorded and a database has been established in order to make sure data validity. Overall, above 30 hours recording and 250 pages of transcript have been gathered from 2018 to 2019. After performing each interview, a transcript copy and case report have been sent to respondents to control errors and make sure validity of gathered data. T-test analyses revealed that these groups had no remarkable difference in provided answers showing that there was not systematic difference between early and late given answers. The collected data was triangulated with obtained information from different observational and secondary sources, such as firm websites, online reports and information, websites, presented materials by informants (archival data, internal memo and company brochure).

Case firm selection

According to discussions of [9], a multiple case design has been employed that composed of 125 new product development projects from total 85 manufacturing firms within 8 different industries in Spain. Also, for case selection, the presented replication logic by [11], was employed. Such information-oriented technique was considered in order to improve information exploitation from small samples and simple cases [12].

Data Collection

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

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

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

Analysis and research findings

Transforming data into fuzzy sets

In order to transform conventional variables to scores of fuzzy membership, we calibrated the variables for membership sets level of various cases to obtain scores ranged from 0.00 to 1.00. Also, interval scale variables have been converted to fuzzy set membership scores via fsQCA software that calibrates functions together with detailed process. In order to calibrate variables, scholars introduced interval scale variables values which correspond to three key qualitative anchors for structuring the fuzzy sets: cross-over point (fuzzy score=0.5), full non-membership threshold (fuzzy score=0.05) and full membership threshold (fuzzy score=0.95). The high ambiguity is identified if a case is more out or more in of sets. For defining these qualitative anchors, we suggest a rationale for each single breakpoint. In order to match calibration of fuzzy set by means of five-point Likert scales used in this study to evaluate project performance, original values were set of 5.0, 1.0 and 3.0 for respectively full-membership, full non-membership and also cross-over anchors.

3. 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 following explanations on 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.

Patterns of knowledge source envelopment

According to predictions, the collaboration amount between various knowledge sources relatively, with various functions is different in project phases. It means that various functions are considered to have a key role to resolve various types of uncertainty and complexity at NPD project stages. Therefore, being dependent to an internal functional department as well as its interest to have collaboration with other sources of external knowledge, seem to be different in NPD project stages. As predicted, external collaboration levels with sources of external knowledge have been increased in both early and latest 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. Both 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 contribute firms to choose 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.

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

Configurational path to speed performance

The findings revealed that if firms are interested in shorter time to market for new products so three configurational paths can be developed to achieve efficient results. The first path with raw coverage 0.29, unique coverage 0.03 and raw consistency 0.95, demonstrates that including customers in both first and last NPD project phase has remarkable impact to increase project speed. The second path suggests to include customers in last phase and in second phase universities can be included, organizations can decrease time to market. The raw consistency, raw coverage and unique coverage of the configuration are respectively 0.9, 0.19 and 0.02. Besides, last configuration reveals that if organizations in first and second NPD project phases have external collaboration with suppliers and also include customers in last project phase, they will be able to decrease time to market of 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.

Configurational path to market performance

In order to obtain market performance, firms generated a configuration with solution coverage 0.88 and solution consistency 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 have collaboration with universities in both first and second NPD project phases and involve customers in last NPD project phase.

Configurational path to product novelty

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

4. Discussion

This study defined two fields in literature of open innovation as important areas to be investigated more at NPD project phases. First one was knowledge achieved by a variety of external sources, previous studies show that for number of actors there is an upper limit, with no ability to identify how to combine sources. Second one was impact of project performance combination, again literature highly emphasized on impacts of external collaboration on total project performance, however it did not concentrate on configurational impacts of external collaboration in NPD project phases and its impact on total project performance. Investigating these two fields in different phases of project, show that we might contribute to previous studies by demonstrating negative impacts of including a source type 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 for such 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 according to type of knowledge that we are seeking for and again it is related to NPD project objectives: it is to minimize costs and also have collaboration with customers in both first and last project phases and suppliers in second project phase; it is to obtain better market performance and product novelty, then select various types of configurations and not just collaborate with universities and suppliers from start of a project.

The empirical findings from research questions about how external sources' combination in project

phases impact project performance in new product development, suggest that including the customers in NPD project will result in better project performance which is in line with literature that revealed the customer involvement in new product development projects have positive impact on better project performance [6].

Time of involving customers in project is more important than customer involvement in order to achieve better outcomes. According to findings customers are considered as a primary knowledge source that can provide critical information in NPD project phases which is in line with achieved results by [7], however the results of customer collaboration are different in each project phase. Customer involvement in both first and last project phases and combining it with supplier involvement in second project phase can decrease project costs, while customer collaboration in 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.

involve many knowledge sources in NPD project phases to achieve an optimum performance. Here, we can show advantages of a particular external sources combination in different phases, which expands achieved results from literature at firm and project level [10].

5. Conclusions

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 (32). This research is aimed to fulfil this gap in previous studies. This research has

Competitor involvement in third project phase can suggest important knowledge for production and if in commercialization phase, such knowledge is combined with customer market knowledge, so project costs can be reduced. In case of universities that propose scientific knowledge rather than market knowledge, according to results, their involvement in both first and second project phases and combining such scientific knowledge with market knowledge achieved from customers will improve market as well as project's cost performance.

These outcomes are in contrast with achieved outcomes by Knudsen and Mortensen (2011), who identified that combining market and science sources can have negative impact, however they did not consider these collaborations in new product development projects. The contribution of this study to literature is analyzing the data in different project phases as well as to decompose project performance to various dimensions. Therefore, we can choose most effective configuration to

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 analysing involvement of these sources of knowledge in project levels of the firm.

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