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Relations between open innovation and product quality: an empirical study of Japanese electronics firms

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Abstract

In late years, the concept of open innovation receives attention from industry and academic. This concept means that firms utilize resources outside for their R&D beyond their boundaries. Behind this background is the fact that firms have more opportunities to utilize resources outside. Previous studies indicate that by utilizing resources outside, firms could make R&D process more efficient or create new products. On the other side of the coin, we have to solve some aspects in open innovation context. First, product quality on the basis of activities of open innovation has to be defined. The definition of product quality is still unclear; thus, it is necessary to identify product quality in open innovation context. In addition, comparison between open innovation and in-company cooperation is not done so much. In the examination of effectiveness of open innovation, we should compare utilization of resources outside with that of in-company ideas. In this paper, we quantitatively analyze relations among product quality, utilization of resources outside, and utilization of internal resources on the basis of Covariance Structure Analysis. This analysis is based on a questionnaire survey at Japanese electronics firms in July 2015.

Keywords: Open innovation, Product quality, In-company cooperation, Covariance structure analysis

Background

Japanese manufacturing firms have utilized technical capabilities in the new product development process, and they have built competitive advantages against foreign companies [26]. However, in recent years, there is a condition that their capabilities do not contribute to make new products. It is required to find and use new opportunities in the new product development process.

To complement technological capabilities, various firms tend to adopt open innovation. Particularly in high-tech manufacturing sectors, open innovation is more widely adopted [6]. In late years, the concept of open innovation receives attention from industry and academics. This concept means that firms utilize resources outside for their R&D beyond their boundaries [2]. Behind this background is the fact that firms have more opportunities to utilize resources outside. Previous studies indicate that by utilizing resources outside, firms could make R&D process more efficient or create new products [3, 28].

Although the concept of open innovation receives attention, Japanese firms have a strong trend to improve their technological capabilities or make new products only by themselves [17]. This trend is like "Not Invented Here" syndrome [19] which is a negative attitude to knowledge that originated from others outside [20]. For this reason, some researchers mentioned that Japanese firms depended on their own resources and they do not tend to adopt open innovation.

Although there are negative opinions about Japanese style, if they had plentiful internal resources, they should use more internal resources than resources outside with in-company cooperation. Some Japanese manufacturing firms have different departments in-house and there might be plentiful opportunities to utilize different resources with in-company cooperation [25]. Now, few researchers compare the effectiveness of open innovation with that of in-company cooperation. Therefore, we think that it is necessary to clarify the importance of open innovation in Japanese manufacturing firms through comparing with in-company cooperation. To clarify it, we also focus on product quality in the context of open innovation because it is necessary to judge the performance of open innovation or in-company cooperation. Based on some factors about open innovation or in-company cooperation, we set the hypotheses and propose one model.

In order to verify our hypotheses, we quantitatively analyze relations among product quality, utilization of resources outside and in-company cooperation on the basis of Covariance Structure Analysis. This analysis is based on a questionnaire survey at Japanese electronics firms in July 2015.

Our paper is structured as follows: first, we present a literature review of open innovation, creativity of members, in-company cooperation, and product quality. Next, we set our hypotheses and explain the proposed model. Then, we show the results of our survey and Covariance Structure Analysis. Finally, we address our conclusion and future research.

Theoretical framework and research model

In this section, we show previous theories or researches about open innovation or new product development. After we explain about factors about open innovation or new product development, we propose one model in this work. In some parts, we mainly focus on customer needs, cooperation with others outside and product quality in the context of open innovation. In addition, we pick up the importance of creativity of members and in-company cooperation in the new product development process. In particular, in-company cooperation is important in Japanese manufacturing firms.

Open innovation

Open innovation as a term and a concept emerged in 2003 and has received a significant amount of attention [2]. Particularly in high-tech manufacturing sectors, open innovation is more widely adopted [6]. 90.91% of executives participating in this study reported that their firms practice open innovation [5]. Chesbrough's original definition is "the purposive use of inflows and outflows of knowledge to accelerate innovation in one's market, and expand the use of internal knowledge in external markets, respectively" [10].

In previous studies, it is said that open innovation depends on "business model" [3, 9]. Business model is a source of value for customers, and firms focus on the importance of customer needs. So as to activate business model, companies are trying to find the resources outside. Particularly in the concept of business model from aspects of customer needs, it is important "what kinds of values firms should provide." or "for what purpose products help customers". Firms trying to identifying customer needs may attempt to take advantage of external technologies. Therefore, there may be relations between identifying customer needs and utilization of resources outsides.

Open innovation is mainly clarified into two types. One is "inbound open innovation" and another is "outbound open innovation" [7]. Inbound open innovation by opening the innovation process in R&D can be defined as a purpose to acquire many external resources [4]. Outbound open innovation means that by placing the specific assets and projects outside, it is possible to save the time and money which are taken for your own projects and get opportunities to nurture relationships with external partners [8]. As this work is about utilization of resources outside and comparison between utilization of internal resources and that of resources outside, we focus on inbound open innovation.

So far, we have explained about the concept of open innovation. What are the merits of open innovation in the new product development process? Firstly, with external technology, firms can reduce cost and time [3, 28]. When adopting open innovation, firms make use of technologies from the external market. Secondly, firms can produce new products with different resources outside. By utilizing different ideas or technologies, firms develop new unique products and differentiate with other firms.

Creativity of members

In the context of Open Innovation, there are a few researches mentioning creativity in the organization, but creativity in the organization highlights the performance of new product development. What is the creativity in the organization? Creativity is defined as "the condition that the members in the organization, while communicating their intention with others, try to achieve the purpose and value which is shared in the organization" [31].

In particular, creativity is defined as "the ability to generate new ones that did not exist previously" [24]. If each member has creativity, new ideas or inventions are developed [29]. In order to get ideas from a new angle to develop creativity in the organization, it is important to facilitate an environment to create a new combination. For example, by interacting with researchers in firms or outside, members get new combinations. A meeting place with such researchers or attending to domestic and international conferences play a role to make new combinations.

To summarize our discussions about creativity, it can be seen that creativity in members is so important to generate new ideas in the new product development process. To generate new ideas, it is often effective to facilitate an environment that stimulates new combination.

In-company cooperation

If Japanese firms had many opportunities to use various resources only in their firms, it would be more effective for Japanese firms to use internal cooperation than open

innovation. Niwa mentions raising one word "semi-open innovation" as a keyword; it is important for internal cooperation within Japanese companies [15, 25]. "Semi-open" means open in a limited range. Some Japanese manufacturing firms have different departments in-house. Such departments are often independent, but it is possible that by connect different resources beyond departments, Japanese firms find new business opportunities. Given this condition in Japanese manufacturing firms, it is necessary to confirm the importance of in-company cooperation beyond different departments.

Product quality

In this subsection, we discuss product quality in the context of open innovation. Some researchers refer to specifics about new products. In R&D process, firms need insight into the needs of their customers, together with the technical capability to act on those insights [11, 27]. Connecting customer needs with technologies makes firms to develop unique products. New product development process is a process of linking technology and customer needs, so it requires that firms bring together the knowledge related to both technology and customers [12]. Even in the new product development process through open innovation, firms also try to make unique products with different resources outside. Considering that open innovation is the process that firms try to use different ideas, knowledge or technologies which do not exist in their firms, through open innovation, the uniqueness of products may be confirmed.

From our discussion about the performance of open innovation, one of the good product qualities is maybe "uniqueness". It is required to confirm whether new products used with technologies outside are unique or not.

Proposed model and hypotheses

Based on our discussions, we set proposed model for analysis. We explain factors to set hypotheses. First of all, considering from previous studies about open innovation, "customer needs" might be a trigger to use resources outsides [3, 9]. If members understood the importance of customer needs, members would utilize different resources to satisfy with customers. So identifying customer needs influences cooperation with others outsides. In addition, Japanese firms may get different resources beyond internal boundaries because some Japanese firms have same departments in-house and various resources [15, 25]. Instead of utilization of resources outsides, it is possible to use internal resources through in-company cooperation.

Cooperation with internal members or external partners provides opportunities to make creativity of members. Communicating or interacting with new people makes members create new ideas about new products. Relations between creativity and cooperation with others are confirmed in some researches. In particular, Japanese firms have many opportunities to use internal cooperation, so when cooperating, it may be effective to interact with others in company.

Lastly, we have to mention about uniqueness of new products. In previous studies, it is mentioned that connecting customer needs with technologies makes firms to develop

unique products [11, 12, 27]. Identifying customer needs may contribute to nurture uniqueness of products. On the other hand, creativity of members may directly influence the uniqueness of new products [29]. Creativity like new ideas is a basis of making new products.

From these discussions, our proposed model is shown in Fig. 1. This is based on five hypotheses.

H1: The more members try to identify customer needs, the more members try to use opportunities to cooperate with others outside.
H2: The more members try to identify customer needs, the more members try to use in-company cooperation.
H3: In-company cooperation is more effective to highlight creativity of members than cooperation with others outside.
H4: The more members have creativity, the more organizations produce the new unique products.
H5: The more actively members try to identify customer needs, the more unique products are in the new product development process.

Research methodology and results of covariance structure analysis

Our research is an empirical study that investigates the activities of open innovation and in-company cooperation among Japanese manufacturing firms. Among Japanese manufacturing firms, we focused on big- or medium-sized electronics firms. To assess the relations in our hypotheses, a questionnaire of 110 question items for each question type was designed. We used six-point Likert scales and structured questions to evaluate the question statements. The scale was assigned values from 1 to 6. For all questions, 1 means strongly disagree and 6 means strongly agree.

The mail survey was administered to big- or medium-sized electronics firms in Japan. It was conducted from July 2015 to August 2015. In order to collect questionnaires, we

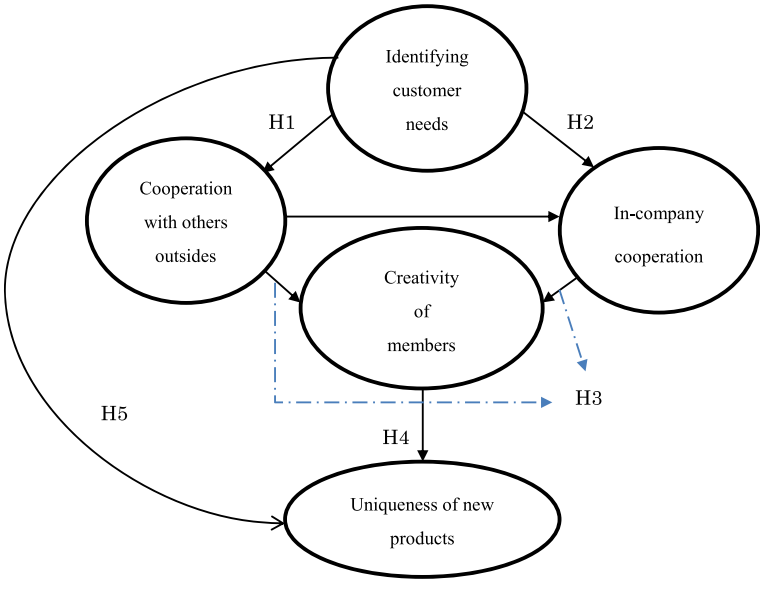

Fig. 1 Proposed model of analysis

Table 1 Response sample composition

Classification	Description
Company size	Large (Capital >300 million, the number of employees > = 300) and medium-sized firms (Capital >100 million, 100 = < the number of employees <999)
Industry type	Electronics (In Japan)
An attribute of respondents	The president or the manager who involve in new product development process in last 3 years
Response rate	12.49% (114 questionnaires)

selected 891 companies. Such companies were listed in the eol database [13] provided by Pronexus Inc. We mailed 888 people and requested 25 people by e-mail. The survey was directed to the president or the manager who involve in new product development process in the last 3 years. We collected 133 questionnaires and eliminated incomplete responses from them. In the result, 114 questionnaires were used to analyze (response rate: 12.49%). In the Table 2, questionnaires we used are shown. All questionnaires are based on previous empirical researches. Questionnaires about customer needs were based on activities about members toward customers [23]. Questionnaires about "Cooperation with others outsides" were based on surveys about open innovation [16]. Questionnaires about "In- company cooperation" were based on internal opportunities to utilize resources. [18, 30]. About creativity of members, we chose some factors of creativity in the new product development process [32]. As of new products, we refer to determinants about uniqueness or novelty [23] (Tables 1 and 2).

Table 2 Questionnaires used for analysis

Model construct	Mean value	Standard deviation
Identifying customer needs		
Estimation of customer needs	3.71	1.01
Technological skills adapted with customer needs	3.87	1.04
Flexible support for customer needs	4.11	1.08
Cooperation with others outsides		
Opportunities to develop new products with others outsides	3.68	1.42
Systems to accept proposals from others outsides	3.40	1.32
Capabilities to connect own technologies with technologies outsides	3.23	1.18
In-company cooperation		
Communication across departments to communicate technological knowledges	3.54	1.26
Utilization of project teams which is across organizations	3.82	1.41
Utilization of project teams which is across organizations	3.73	1.28
Creativity of members		
Generation of innovative ideas	3.72	0.96
Findings about new ways to use facilities	3.80	0.95
Uniqueness of new products		
Number of novel products	3.02	1.34
Unique specifics of new products	4.03	1.12
Useful functions of new products	4.14	0.98

Table 3 Results of reliability analysis

Construct	Cronbach's alpha
Identifying customer needs	0.710
Cooperation with others outsides	0.602
In-company cooperation	0.638
Creativity of members	0.730
Uniqueness of new products	0.719

Covariance structure analysis

The structural model hypothesized in was tested using AMOS. Before using AMOS, we confirmed undimensionality and reliability about scales. After scales were validated to use to analyze, we conducted Structural Model Analysis.

Unidimensionality analysis

Unidimensionality is a necessary condition for reliable and valid scales. Measurement scales are considered to be unidimensional if the items in the scale measure a single construct. The goodness of fit index (GFI) and comparative fit index (CFI) are often used to judge scale undimensionality. Values of 0.90 or greater indicate a strong fit [14, 22]. From our results, GFI indicates 0.904 and CFI indicates 0.960.

Reliability analysis

Reliability is known as the consistency of the measurement. To assess reliability of the items, it is possible to confirm the quality of construct measurement. For this purpose, we calculated Cronbach's alpha for each scales. If the scale had a strong alpha value (>0.70), the items were validated. Scales about the constructs "Identifying of customer needs", "In-company cooperation" and "Creativity of members" showed alpha values greater than 0.70, so they have strong alpha values. On the other hand, scales about "Cooperation with others outside" and "In-company cooperation" showed alpha values lower than 0.70. Although their values were a bit low, they were than 0.60 so we thought their values were acceptable [21] and used (Table 3).

Structural model analysis

Root Mean Square Error of Approximation (RMSEA) is often used as a measure of discrepancy per degree of freedom. Its value of 0.05 indicates a close fit and that values less than 0.08 show reasonable errors of approximation in population [14]. RMSEA values in our model were 0.046, so its value indicates a close fit. In addition, our value of CMIN/DF was less than 2. If this value is less than 2, it indicate a reasonable fit

Table 4 Goodness of fit indices

Goodness of fit indices	Value
GFI	0.904
AGFI	0.855
CFI	0.960
RMSEA	0.046
CMIN/DF	1.243

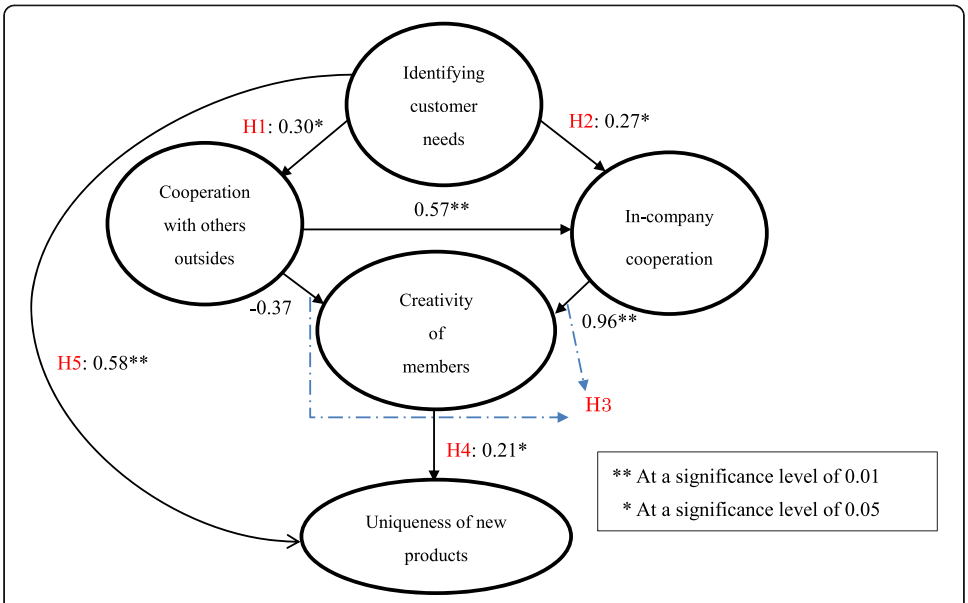

Fig. 2 Model Results

between the hypothetical model and the sample data [1]. Thus, indicative of an acceptable fit was validated (Table 4).

From our results shown in Fig. 2 and Table 5, the construct "Identifying customer needs" influences the constructs "Cooperation with others outsides" and "In-company cooperation" (Standardized coefficient: 0.30 and 0.27 respectively). Although the construct "In-company cooperation" has a significant effect on the "Creativity of members" (Standardized coefficient: 0.96), the "Cooperation with others outsides" does not directly influence the "Creativity of members" (Standardized coefficient: −0.37). The pass from "Cooperation with others outsides" to "Creativity of members" does not show a significant effect. However, the pass from "In-company cooperation" to "Creativity of members" show a significant effect. Additionally, when calculating a total effect from an indirect effect and a direct effect of "Cooperation with others outsides" on "Creativity of members", a total effect shows a positive value (Total effect: 0.18). From this aspect, we can also consider that Hypothesis 3 is validated. However, since the "Cooperation with others outsides" has a significant effect on the "In-company cooperation" (Standardized coefficient: 0.57), the "Cooperation with others outsides" indirectly affects the "Creativity of members" through the "In-company cooperation" and we could found the mediating effect. In addition, the "Creativity of members" has an effect on "Uniqueness of new products" (Table 6).

All results showed support for hypotheses and our theoretical model.

Table 5 Values of three effects

Effects	Value
Direct Effect	−0.37
Indirect Effect	0.55
Total effect	0.18

Table 6 Summary of Results

Model hypotheses		Results
H1:	The more members try to identify customer needs, the more members try to use opportunities to cooperate with others outsides.	Supported ($p < 0.05$)
H2:	The more members try to identify customer needs, the more members try to use in-company cooperation.	Supported ($p < 0.05$)
H3:	In-company cooperation is more effective to highlight creativity of members than cooperation with others outsides.	Strongly supported ($p < 0.01$)
H4:	The more members have creativity, the more organizations produce the new unique products.	Supported ($p < 0.05$)
H5:	The more actively members try to identify customer needs, the more unique products are in the new product development process.	Strongly supported ($p < 0.01$)

Conclusion and future research

Through our analysis, our hypotheses were verified. As discussed in the process of making hypotheses, in-company cooperation seems to be more effective than cooperation with others outsides in Japanese big or medium-sized firms. Such firms may have many different resources and knowledge in their own firms. Through sharing with members in other divisions or departments, members may obtain new ideas and utilize such ideas to make new products.

In this analysis, Japanese electronics firms seem to utilize in-company cooperation more effectively than cooperation with others outsides. In addition, by using such cooperation, Japanese electronics firms enhance creativity of their members who involve in their new product development process and they produce new products which is unique in their market. This result implies that Japanese big firms have many potential opportunities to use resources in their own companies because they have several different departments and different resources or knowledge.

We have some tasks to research in the future. First of all, we have to research about relations among other product quality, open innovation and in-company cooperation. In this paper, we focus on a part of the definition of product quality. Although we revealed relationships among the constructs “the uniqueness of new products”, “open innovation” and “in-company cooperation”, we could not solve the other relationships.

Secondly, we chose only electronics firms in Japan in this work. In our opinion, such firms are representative example in manufacturing firms and we focused on them. But there are various firms which are different from electronics firms. In the future, by collecting questionnaires from other manufacturing firms, we’d like to compare Japanese firms.

Lastly, we made proposed model and questionnaires from conventional theories. In the researches of Open Innovation, only few works refer to in-company cooperation or product quality of new products and quantitative researches are still few. It is required to refine our model or questionnaires with this research.

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Authors' contributions
TI (Corresponding author) designed the study, wrote the initial draft of the manuscript, contributed to analysis and interpretation of data. HS assisted in the preparation of the manuscript, contributed to interpretation, and critically reviewed the manuscript. The final version of the manuscript was approved by both authors.

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Competing interests
We declare that we have no competing interests.

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