© June 2017 | IJIRT | Volume 4 Issue 1 | ISSN: 2349-6002

The Impact of user innovation on new product development project success in Japanese firms

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***Abstract*— This study aims to investigate the impacts of user innovation practice on NPD project success in Japanese manufacturing firms before Lehman Shock. Specifically, a conceptual model at firm level analysis is proposed, consisting of four phases in which a linear process (1) degree of new product newness to the firm (marketing newness and technical newness); (2) research and development strategy; (3) user innovation (user expertise, user innovation implementation); (4) NPD project success (effectiveness and efficiency). Our model is suggested and tested with structural equation modeling, using the empirical data which was collected from 126 Japanese manufacturing firms in 2008. The results indicate that user expertise and the implementation of user innovation have a significant effect on the efficiency of NPD projects. However, neither R&D strategy nor the degree of product market, technological newness management is related to user innovation implementation. Moreover, we find support for the effectiveness of NPD projects is positively affected by NPD efficiency.**

***Index Terms*— User Innovation, Japanese firms, new product development (NPD) project success, structural equation modeling (SEM)**

I. INTRODUCTION

Since the concept of user innovation was theoretical documented in "The Sources of Innovation" [1]. Prior literature emphasized the importance of user innovation [2],[3], and as a source of novel technologies and products innovation literature[1],[4].

As a form of innovation, user innovation has been documented in large-scale, multi-industry firms developing process innovations [5], [6], and conducting surveys [5], [7], [8]. Moreover, the positive impact on users as innovators on NPD success has been established in research and practice[9]-[11]. This means in a wide variety of product domains, that users are a critical and frequent source of NPD project.

Additionally, [12], [13] have suggested that innovative ideas or creating prototypes of innovative products from users, and collaborations [14], [15] with users can be utilized in NPD processes and develop new business models.

However, these empirical studies are based primarily on Western firms and focus on industries level. In addition, relatively little works have indicated the relationship between user innovation and NPD project success of Japanese firms. That means it is not

clear, though, whether the factors identified by previous studies can be applied to the industries in Japan.

In this vein, the purpose of this paper is to reveal the impact of user innovation on NPD project success. In particular, we articulate the factors of the degree of product market, technological newness, R&D strategy, user expertise and NPD project success in our model. In the data considered, we collected the empirical data from Japanese manufacturing firms in particular unique period, which is before the economic recession in 2008. Then, we analyze the conceptual model with partial least squares-structural equation modeling (PLS-SEM) [16], [17] .

The paper contains four sections. We first introduce the background of research in section 1. In section 2, we develop the hypotheses and conceptual model which are based on the results of the literature review. Section 3 describes research method. In section 4, we present the analysis results. Discussions are made in section 5. In section 6, this paper closes with conclusions.

II. CONCEPTUAL MODEL AND HYPOTHESE

A. Construction of model

In this section, the research framework (Figure 1.) is developed based on the comprehensive review in NPD projects success and user innovation.

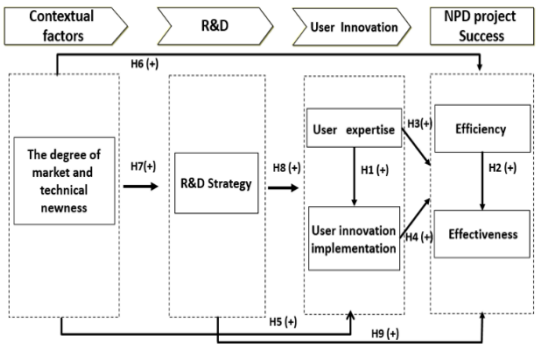

Figure 1. Conceptual framework

In particular, we contributed to illuminating the importance of factors such as R&D and the degree of new product's newness, which effect on the user innovation. The factor user innovation [11] in this model refers to user expertise and the implementation of user innovation. Two factors for NPD success at the project level are considered: efficiency and effectiveness[18], [19]. In addition, the model proposes three key front end factors that determine NPD projects' effectiveness and efficiency: the degree of newness, R&D strategy, and the user innovation.

B.User expertise

From the user's perspective, as key collaborative partners. [20] identified that potential customers cannot easily articulate needs to a new product concept. Whereas, [21] revealed that firms empowering their customers during NPD enhance competitive advantage in the market place.

Specifically, customers are so-called 'lead users'-at the leading edge and early phases of innovation projects, sufficiently well innovative and motivated to make significant contributions to the NPD or services have become important [1], [21]- [23].

Moreover, [22] argued that lead users contributed to the design and development of products. At new

product idea generation phase, several published studies have reported that lead user-centered approach played a critical role [23]- [26]. [24] also found that lead user approach significantly positive impact on the newness of innovation, the expected turnover, the market share, and the strategic importance of 3M Company.

From the firm's perspective, recent studies have identified that lead users with high level of innovativeness characteristics such as: being ahead of a target market trend, high expected benefits, user expertise and motivation, extreme user needs as well as opinion leadership should be integrated into the firm's NPD process [27]. Not only lead users, ordinary users can also provide valuable ideas for NPD. Futermore, [28] further explicitly studied the value of user versus professional ideas emerging in a crowdsourced NPD process, showed that, while ideas developed by professionals in the firm tend to be more feasible, user ideas exhibited a higher degree of novelty and promise clearer customer benefits.

C. User expertise and User innovation implementation

The literature on user innovation generally defines users as economic actors— which can be both firms and consumers—that expect to benefit from using a certain technology, in contrast to selling it [11]. Based on previous research[29]- [30], a strong correlation between lead users and user innovation was found. Futhermore, [11],summarised that user innovations in general, as well as commercially attractive ones in particular, tend to be developed by lead users.

Therefore, we hypothesize that:

H1: The user innovation implementation is positively affected by high level of user expertise.

D. NPD Project success

According to [19], there are two key factors as measurement of success : efficiency and effectiveness. The NPD project efficiency is a function of the degree to which the NPD project can economically transform inputs into outputs, respondents assessed the degree of agreement between financial and personnel resources. Effectiveness is related to corporate image, target market share, and customer satisfaction, and emphasizes a long-term outcome [31].

In this study, efficiency refers to cost-efficiency of technologies; required technological support; quality of applied technologies;lead time efficiency, while effectiveness refers to meeti profit targets, sales volume targets, market share targets and customer's satisfaction.

E. NPD project efficiency and project effectiveness

Several empirical researches showed a strong correlation between success factors, effectiveness of the NPD projects is positively affected by efficiency of NPD projects [19], [32]. Thus, here comes hypothesis 2:

H2: The effectiveness of NPD project is positively affected by NPD efficiency.

F. User innovation and NPD Project success

Not only the users with high level of capability and motivation are prompted to become the initial developers of NPD [33], users who have previous knowledge and stored experience in creative problem solving are also concerned[22].

Accordingly, [34] based on their conceptual

framework (see in Figure 2.), and examined the user-oriented design (UOD) contribute positively to NPD.

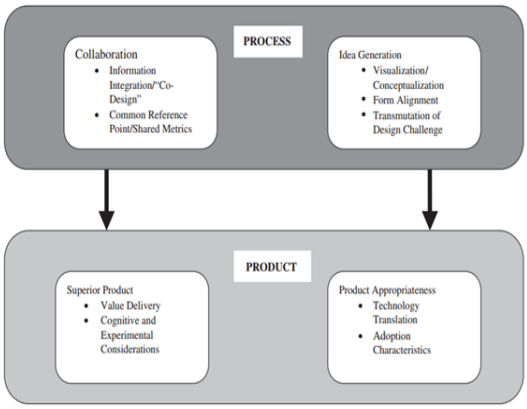

Figure 2. User-Oriented Design Impact on NPD in Veryzer and Mozota (2005)

As user intergration has been emphasized in a study of essential activities in NPD. There might be strong causal relationship between the user innovation and the NPD project success. However, little was known about the relationship bewteen user expertise and efficiency or effectiveness of NPD. Hypotheses 3 and 4 are as follows:

H3a: The efficiency of NPD project is positively affected by high level of user expertise.

H3b: The effectiveness of NPD project is positively affected by high level of user expertise.

H4a: User innovation implementation is positively related to the efficiency of NPD project.

H4b: User innovation implementation is positively related to the effectiveness of NPD project.

G. Degree of product market, technological newness

Several studies clarify that the difficulty of a project could change according to the product newness or innovativeness [19], [32]. Regularly, highly innovative products are signified as having a high degree of newness, notably as market and technological to the perspective of the firm[35]. Similarily, the product newness is consisted of technology newness and market, based on the conditions existent at the time of each product's development. Moreover, technological and marketing resources were found as newness elements of new products innovation.

In this study, we adopt 'degree of market newness' (difference in target market, distribution channels, and advertisement of new product), 'degree of technical newness' (difference in technical components, product lines, processes and knowledge required) to analyze.

H. Degree of product market, technological newness and User innovation

The degree of newness of a product determines how much information must be gathered by a firm to develop a new product. As users can be functionally fixed to their current use context and therefore unable to develop radically new ideas [22]. On the other hand, it is difficult for users to validly evaluate concepts and prototypes of the high degree of technological newness.

Thus, based on previous research, the degree of a product newness and user innovation activities are might strongly correlated. We hypothesize that:

H5a: The high level user expertise is positively affected by the high degree of product market, technological newness.

H5b: The user innovation implementation is negatively affected by the high degree of product market, technological newness.

I. Degree of product market, technological newness

and NPD Project success

The degree of newness or degree of innovativeness of a NPD project was identified as a key contextual factor[19], [32].

Several studies provide the negative link between the degree of product market, technological newness and the NPD project success [32], [36]. Researchers state that the higher the degree of newness more uncertainty exists in the NPD process. Consequently, the difficulty of execution results in higher degree of failure.

Therefore, we hypothesize that:

H6a: The efficiency of NPD project is negatively affected by the high degree of product market, technological newness.

H6b: The effectiveness of NPD project is negatively affected by the high degree of product market, technological newness.

J. Degree of product market, technological newness and R&D strategy

[37] demonstrated that a new market or new technology can be attacked by a task force led by R&D. Further, technological newness was related to a content of R&D in the products.

Therefore, we hypothesize that:

H7: Degree of product market and technological newness are positively related to R&D strategy.

K. R&D strategy and User innovation

[38] designed a model of R&D strategy with user innovation activities, revealed that producers' optimal R&D strategies yield a suboptimal division of innovative labor between users and producers at the societal level.

Therefore, we hypothesize that:

H8: R&D strategy is positively related to user innovation implementation.

L. R&D Strategy and NPD Project success

A relatively high rate of NPD Project success is originated from marketing and customers as compared to ideas originating from R&D, suppliers, and managemen. [39] based on the model developed by [40], conducted a Partial Least Squares (PLS) analysis on Slovenian companies with different NPD characteristics, and confirmed that NPD success is influenced by the level of R&D. Similarly, [41] tested at firm level with SEM demonstrated that the internal resources such as R&D management mediates the impact of the end-user collaboration and breadth of external collaboration on NPD.

Therefore, we hypothesize that:

H9a: The efficiency of NPD project is positively affected by R&D strategy.

H9b: The effectiveness of NPD project is positively affected by R&D strategy.

III.METHODOLOGY

A.Sample and data collection

The hypotheses were tested by analyzing a sample of data, collected from Japanese manufacturing firms in 2008 (126 usable samples out of 351 respondents with a response rate of 35.9%). They had between ranging from 1,061 to 20,000,000 million Japanese Yen. The majority of the respondents consisted of medium to large companies having annual sales between 100 billion and 10 trillion yen (JPY) as shown in Figure 3. Meanwhile, their employees

ranging between 70 and 328,645 (Figure 4).

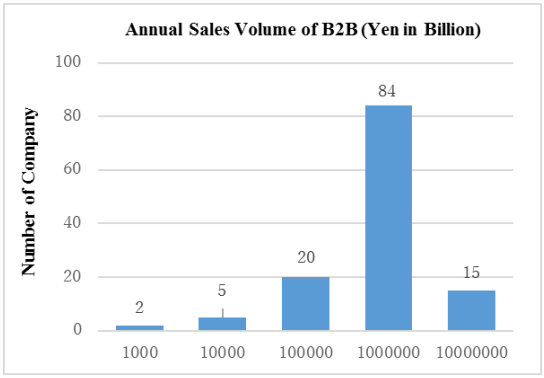

Figure 3. Annual volume of sales

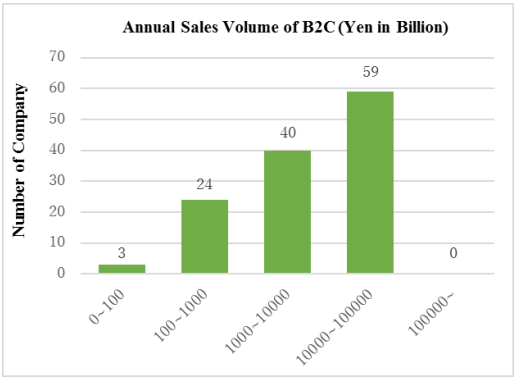

Figure 4. Number of employees

For the survey items, respondents were given the survey to answer the indicator questions on a 7- point Likert-type scale of 1 ("strongly disagree") to 7 ("strongly agree").

B. Research method

We inferred that Partial Least Squares Structural Equation Modeling (PLS-SEM). PLS-SEM approach (Smart PLS 2.0 statistical software package), as against Covariance based (CB)–SEM in our study for the following reasons. Firstly, PLS trades in optimality for consistency in the statistical inference [16]. Secondly, PLS is distribution free, and allows for the estimation of relationship between latent variables for small sample size [42]. Recommendations of PLS for the minimum number of observations range from 30 to 100 cases.is distribution-free, and achieves higher statistical power with smaller samples. Moreover, PLS supports a complex model design, and is more appropriate for the exploratory nature of our study (Lee et al., 2006; Ringle et al., 2012).

IV. MODEL TESTING ANS RESULTS

A. Measurement Assessment

Assessment of our measurement models includes Cronbach's alpha, composite reliability to evaluate internal consistency, individual indicator reliability, and average variance extracted (AVE) greater than 0.5 is preferableto evaluate convergent validity [42]. These results are provided in the Table 1. The common quality requirements were met by almost each of the constructs. Thus, it is can concluded that the measurements are reliable for data of Japanese firms.

	AVE>0.5	Composite Reliability>0.7	R^2	Cronbachs Alpha>0.6	Communality >0.5
Newness	0.64821	0.846545	-	0.737986	0.64821
R&D strategy	0.583819	0.844513	0.210834	0.754053	0.583819
User expertise	0.592069	0.896608	0.024597	0.860908	0.592069
User innovation implementation	0.514609	0.912386	0.684727	0.891839	0.514609
Efficiency	0.627775	0.930544	0.535485	0.914021	0.627775
Effectiveness	0.726177	0.840557	0.101191	0.637435	0.726177

Table 1. Measurement assessment (Calculation with SmartPLS 2.0)

B. Result of direct and total effects

Bootstrapping analysis was undertaken to ascertain crossloadings to get t-values [42], using 5000 sub-samples as prescribed by [16]. With the analysis of the measurement model being satisfactory, it was then proceeded to analyze the structural model,

the analysis results of total effects are displayed in Table 2, which summarizes the results by showing t values and shows the estimated path coefficients, the corresponding significance levels (indicated with asterisks) for correlation coefficients: * $p<0.05$; ** $p<0.01$; *** $p<0.001$. These results provide empirical support for 6 of 13 hypotheses.

Hypotheses		Direct effects				Total effects			
		Path Coeff.	Standard Error (STERR)	t Value	Sig. Level	Total effects	Standard Error (STERR)	t Value	Sig. Level
H1	User expertise -> UI	0.829628	0.02324	35.6978	***	0.829628	0.02324	35.6978	***
H2	Efficiency ->Effectiveness	0.378653	0.137306	2.75774	**	0.378653	0.137306	2.75774	**
H3a	User expertise -> Efficiency	0.198688	0.096131	2.06684	*	0.648806	0.044618	14.5414	***
H3b	User expertise ->Effectiveness	0.06953	0.150728	0.4613	-	0.134227	0.095788	1.4013	-
H4a	UI-> Efficiency	0.542554	0.096374	5.62965	***	0.542554	0.096374	5.62965	***
H4b	UI-> Effectiveness	-0.21814	0.151167	1.44304	-	-0.012701	0.147874	0.08589	-
H5a	Newness-> User expertise	0.156835	0.071731	2.18644	*	0.156835	0.071731	2.18644	*
H5b	Newness -> UI	-0.010678	0.047517	0.22473	-	0.09465	0.074689	1.26726	-
H6a	Newness-> Efficiency	0.089633	0.058041	1.5443	-	0.176574	0.070376	2.50899	*
H6b	Newness-> Effectiveness	0.060801	0.165509	0.36736	-	0.05728	0.201943	0.28365	-
H7	Newness-> R&D Strategy	-0.459167	0.061478	7.46878	***	-0.459167	0.061478	7.46878	***
H8	R&D Strategy -> UI	0.05398	0.050333	1.07247	-	0.05398	0.050333	1.07247	-

Table 2. Parameter estimation (Direct and Total effects) (Calculation with SmartPLS)

V. DISCUSSIONS

Considering the results, it can be seen that six hypotheses (hypothesis 1, 2, 3a, 4a, 5a and 7) were supported. On th other hand, eight hypotheses (hypothesis 3b, 4b, 5b, 6a, 6b, 8, 9a, 9b) were rejected.

Expected positive direct and total effect of user expertise on user innovation implementation is significant in 0.1% level based on data (hypotheses 1), and is proved to be significantly by three stars (***) total effect on the effectiveness (hypotheses 3a). At the same time, the positive effect of efficiency on effectiveness is consistent with previous research (hypotheses 2). On the contrary, user expertise is not related to efficiency, which is another factor of the NPD project success (hypotheses 3b). It can be seen that a significant level direct and total positive effect of the user innovation implementation on efficiency (hypotheses 4a). Whereas, an expected positive direct and total effect of the user innovation implementation on effectiveness is not confirmed (hypothesis 4b).

The positive relationship between the degree of product market, technological newness and user expertise (hypothesis 5a) is weakly supported with one star (*). Inconsistent with previous works, the direct and total negative effect of the degree of product market, technological newness on the efficiency and effectiveness is not supported (hypotheses 6). In contrast to experimental findings, the direct and total relationship between the degree of product market, technological newness and R&D strategy (hypothesis 7) is negative and statistically (-0.4591, $P < 0.001$).

Contrary to expectation, the R&D strategy do not have an impact on the user innovation implementation and the NPD project success (hypotheses 8 and 9 a and b)

VI. CONCLUSIONS

Many studies have been conducted to identify new product success factors, but they did not pay any attention to the success of the efficiency and effectiveness of the NPD project that affected by the success of user innovation implementation. Moreover, few studies had tried to mention the degree of product

market, technological newness as the impact factor on new product success. Besides, there is a consensus among researchers that the R&D strategy is one of the important factors of NPD success. Thus, in this study, based on the systematic literature reviews, we propose the theoretical framework consist of 1) degree of product market, technological newness, 2) R&D strategy and 3) user expertise to empirically tested and analyzed the relationship between the implementation of user innovation and NPD project success.

From the results of the SEM analysis, firstly, we find support for the direct and total effect of user expertise on user innovation implementation and efficiency respectively. However, neither R&D strategy nor the degree of product market, technological newness management is related to user innovation implementation. Moreover, we find support for the effectiveness of NPD projects is positively affected by NPD efficiency. Secondly, contrary to the prediction, the degree of product market, technological newness is significantly negative effect on R&D stragety.

To conclude, considering rapid changes in the economic world in the 2000s, Japanese firms were concentrated on user innovation activities and tended to keep initial plans during development process, consequently, the success is achieved.

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