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Covariance Structure Analysis of Innovation and ICT Use among Japanese innovative SMEs

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Abstract

One of the common features of innovative SMEs identified from our previous surveys and in-depth interviews is innovation capability accumulated inside the firm, which enables them to create new products which meet customer needs and to cooperate with the other firms. The factors that SMEs achieve innovation are complex, and the causal relationships between factors have not been sufficiently clarified yet. This paper attempts to clarify the innovation process using covariance structure analysis, in particular focusing on the role ICT. Seven hypotheses are demonstrated by two models. The results obtained are as follows: (i) top management's participation and employee's motivation in the innovation process promote the effect of introducing ICT; (ii) this effect of ICT use raises innovation capability; in particular ability to connect external linkages; (iii) ICT use, innovation capability and external linkages enhance innovation activity; and (iv) effect of ICT use and innovation capability promote innovation directly. Thus this paper identifies that the effect of introducing ICT promotes innovation, and it is indispensable for innovation in Japanese SMEs.

Four key words: ICT, Innovation, innovation capability, external linkages, covariance structure analysis

1. Introduction

To achieve innovation is essential for sustainable economic development. In

Japan, SMEs (small- and medium-sized enterprises) were placed as an important economic actor in the Reconstruction Japan Initiative decided by the Cabinet Office in July 2012, in which SMEs are expected to grow to global firms and to create employment opportunity in the region. In reality, on the other hand, SMEs have been in the severe situation due to long stagnation. Under these environments, SMEs which achieve the rate of profit more than that of the average big firms are few (The Small and Medium Enterprise Agency, 2009). Such SMEs own some common features such as the strong leadership of top management, quick and flexible decision making, strategy for seeking niche markets, engineer's craftsmanship, and effective use of ICT (Information and Communication Technology). Firm can improve their business process and the efficiency by introducing and utilizing ICT positively. To introduce ICT means just one type of process innovation which includes the adopting the new production method and logistics. Moreover, information of customer needs and rival firms can be promptly obtained by using the Internet and social media, for example. In addition, the communication among employers and top management are activated and the knowledge management inside the firm can be strengthen by ICT, which leads to innovation (Dogson et al., 2006; Lee and Xia, 200; Idota et al., 2012a). However, ICT is not only factor for deriving innovation, since the innovation process is complex.

The innovation is categorized into the following four types according to Oslo Manual (OECD, 2005); (i) product innovation (new product and service); (ii) process innovation (new production method and new logistic method); (iii) Marketing innovation (change in design, packaging, and production sites); and (iv) organizational innovation (business practice, workplace environment, and relationship between the organizations of inside and outside). Since both of product and process innovation are created as a result of organizational innovation, and some of marketing innovation include product and process innovation, this paper discusses both of product and process innovation. Regarding the sources of innovation, on the other hand, lots of previous studies have been analyzing, and based on these, our previous studies identify the following three key factors; (i) innovation capability, (ii) external linkages, and (iii) ICT use. The objectives of the paper are is (i) to define the content of innovation capability of firms and (ii) to analyze how innovation sources contribute to creation on innovation, in particular to examine the causal relationship between three sources and innovation. As presenting in what follows, although there are ample researches on innovation capability, less analyses were conducted in the context of innovation capability and ICT. Moreover, fewer researches focus on the *causal* relationship between the above three sources and the final outcome of innovation. These problems

have not been sufficiently clarified yet. Hence, this paper is tried to analyze the causal relationship by employing covariance structure analysis.

2. Previous literature

Innovation capability is defined as the ability to continuously transform knowledge and ideas into new products, processes and systems for the benefit of the firm and its stakeholders (Lawson and Samson, 2001). Innovation capability consists of various factors which are listed as audit tool for measuring innovation capability, and related factors are categorized into groups; Mariano and Pilar (2005), for example, categorizes as follows: (1) communication with the external environment; (2) level of know-how and experience within the organization; (3) diversity and overlaps in the knowledge structure; and (4) strategic positioning. This paper terms it as innovation capability, which is defined as an integrated ability of a firm to create innovation which consists of all resources, core competence, or competitiveness.

2.1 innovation capability

Traditionally innovation capability was focused on and referred to as “absorptive capacity” by Cohen and Levinthal (1990), Zahra and George (2002) and Christensen and Kaufman (2009), for example. Christensen and Kaufman define it as a firm’s ability to reorganize the value of new external knowledge, assimilate to commercial ends. They also recognize the innovation process is a simple linear learning process which consists of four dimensions; acquisition, assimilation, transformation, and exploitation. Acquisition is a process to identify the relevant information over the total number of information. Assimilation is the ability to process and analyze the information obtained. Transformation is the ability to modify and adopt new knowledge and combine with existing knowledge inside the firms. Exploitation is the ability to transform this knowledge into innovation or competitive advantage. Thus absorptive capability determines the competitive advantage of a firm (Barney, 1991).

Another source of innovation is to make use of factors outside a firm and utilize them to promote innovation capability. New information related to innovation fundamentally is obtained outside the firm, and the literature mentioned above is analyzing this more or less. The collaboration with entities outside the firm such as other firms, universities, and local research institutions in the innovation process came to be the center of research and analyzed in the framework of “open innovation” (Chesbrough, 2003, 2006a, 2006b). The concept of the open innovation process is

developed in accordance with the growth of the assembling and processing industry which deals with numerous parts and components such as the automotive or electronics industries. New information for innovation is conveyed via the supply chain. There are two strategies for obtaining information; one is through transactions with other firms, from suppliers to customers, while another is the collaboration with research institutions (Kagami, Giovannetti, and Tsuji, 2007). In context of “absorptive capacity” and “open innovation,” external linkage is important factor. External linkage is defined as a linkage with other firms to offer the technology each other and to collaborate with other firms.

2.2 ICT use in the innovation process

ICT use is also essential for innovation. ICT has been regarded as a tool that improves the productivity of firms and enhances innovation activities. ICT contributes to firms in the following ways: (i) improving the efficiency of management and communication inside the firm; (ii) enabling networking and collaboration among business entities and organizations by reducing the time required for communication and overcoming geographical constraints; and (iii) creating new markets for business, such as e-commerce. As a result, ICTs have become one of the essential bases for promoting innovation activities (Dogson et al., 2006; Lee & Xia, 2006; Idota et al., 2012a). Moreover, ICT has created new phenomena related to innovation; ICT also activates communication among employees or between employees and the top management within the firm, and accordingly strengthens the knowledge creation process. It is reported that even the use of SNS, Twitter, or blogs by employees promotes innovation (Idota et al., 2011). In addition to ICT use inside the firm, ICT use also supports collaboration with entities outside the firm, which is referred to as “open innovation,” as the above-mentioned. In particular, cooperation with other firms, universities, and local research institutions has been an important focus (Chesbrough, 2003, 2006a, 2006b). In the open innovation process, a strategy for sharing information and resources with other firms, from suppliers to customers, is required. The use of ICT is, therefore, indispensable for the promotion of open innovation, since ICT can connect firms and expedite the sharing of information related to innovation (Tsuji and Miyahara, 2010, 2011; Idota et al., 2010, 2012a). Therefore, these three key factors such as innovation capability, external linkage and ICT use promote innovation activity. As a result, the firms can achieve their innovation.

2.3 Causality between ICT use and innovation

The most of analysis of innovation mainly are based on two methods such as

regression analysis and factor analysis. Although there are various related methods, the underlying basic theory is almost the same. The former is to verify the statistical relationship between observed variables, but its issues are it can deal only observable variables, which raises the problem of endogeneity, and as a result, obtained relationship is “seemingly related,” but not causality. Factor analysis, on the other hand, can deal with endogenous variables, but cannot explain the causality. This paper employs Covariance Structural Analysis which can overcome problems both of regression and factor analysis own.

Although there are papers on innovation using Covariance Structural Analysis, there are few analyses examining the relationship between ICT and innovation using it. For example, Chen (2012) demonstrated the relationship between IT-enabled resources and R&D capability. This paper has various common points with this paper.

3. Model and hypothesis

This paper attempts to analyze how ICT use contribute to innovation. Based on authors' previous papers and papers listed in previous literature, three variables including innovation capability, external linkages, and ICT use are most important sources of innovation. Innovation capability inside the firm contains factors such as technological level, managerial organization, human resources, and so on. In order to identify the representative variables which coincide with above factors, factor analysis is used.

3.1 Data

This paper is based on the mail survey conducted in February 2012 to 3,959 innovative Japanese SMEs in the industries of manufacturing, service, information processing service and construction*. The number of effective replies was 647 (16.3%). Questions in the survey consist of the number of innovations achieved for recent five years, business resources, management behaviors, effect of ICT, and so on.

The aim of the analysis is to verify whether the above seven hypotheses are held or not by using covariance structure analysis. Covariance structure analysis is one of the statistical methods that can examine the causal relationship between plural constructs by making some models. Table 3 indicates basic statistics. Not available data is excluded. “Presence of product innovation” and “Presence of process innovation” are dummy data. The other questions are answered in the Likert five scale.

Table 1. Basic statistics

		N	Min	Max	Avg.	Std. Dev.
Innovation	Presence of product innovation	468	0	1	.71	.453
	Presence of process innovation	468	0	1	.52	.500
Top Management's Participation	The top manager voluntarily shows the idea and decides a new business.	468	1	5	3.71	1.005
	The top manager takes leading to do new business.	468	1	5	3.88	.972
Employee's Motivation	The employee understands the target of the firm.	468	1	5	3.96	.725
	The employee is proud of his/her firm.	468	1	5	3.83	.696
	The employee understands the strong point of the firm.	468	2	5	3.91	.692
	There is atmosphere that consults the colleague easily.	468	1	5	3.77	.782
	The employee understands the scene for which the in-house product is used.	468	1	5	3.92	.829
	Even if it is unrelated to him/her, the employee helps the others' work.	468	1	5	3.63	.806
Innovation Capability	Capability to create new product and service	468	1	5	3.39	1.027
	Capability to solve customer's problem	468	1	5	3.85	.804
	Core original technology and R&D capability	468	1	5	3.57	.912
External Linkage	Positively offering other companies your own technology	468	1	5	2.81	1.098
	Received technical proposals from the other companies	468	1	5	2.81	1.074
	Understanding the strong point of the partner, and collaborating in the field of the strong point each other	468	1	5	3.41	1.061
Innovation Activity	The ideas of the new product and service often create in the firm.	468	1	5	3.18	1.125
	Basic research and R&D are coordinated.	468	1	5	2.75	1.099
	R&D is directly connected to new product and service	468	1	5	2.91	1.146
	Analyzing data of product and service of your company and the competitor	468	1	5	2.94	1.062
Effect of ICT	Usefulness of PR for goods	468	1	5	3.13	1.243
	Speed improvement of managerial judgment and business development	468	1	5	3.43	1.084
	Shortening of product at development period	468	1	5	2.86	1.098
	Increasing in number of new product and service development	468	1	5	2.72	1.049
	Easiness of awareness of customer's needs	468	1	5	3.19	1.059

Source: Authors

3.2 Confirmatory Factor Analysis

In conducting Covariance Structure Analysis, it is necessary to obtain Latent variables. To specify these variables, confirmatory factor analysis is conducted by the maximum likelihood method (Varimax Rotation). The result is shown in Table 2-4. Table 2 indicates Latent variables related to human factor, and as a result, two factors

are extracted in the result of factor analysis of “Top management” and “Employee.” Since the first factor consists of the employee's boast and understanding, and atmosphere of the office and so on, which is termed as “Orientation of employees’ motivation.” As for the second factor, Top Management’ presenting his/her ideas, leadership of the top manager and top manager's participation in project are extracted, and therefore it is referred to as “Orientation of the top manager's participation.”

Table 2. Factor analysis of top management and employee

	Top management and employee	
	Employee’s motivation	Top management’s participation
The employee understands the target of the firm.	.669	.037
The employee is proud of his/her firm.	.742	-.002
The employee understands the strong point of the firm.	.733	.028
There is atmosphere that consults the colleague easily.	.623	-.013
The employee understands the scene for which the in-house product is used.	.536	.034
Even if it is unrelated to him/her, the employee helps the others' work.	.637	-.086
The top manager voluntarily shows the idea and decides a new business.	-.010	.827
The top manager takes leading to do new business.	.009	.908
Factor Correlation Matrix		
1	1.000	.087
2	.087	1.000
Cronbach’s α	.816	.858

Source: Authors

The result regarding the innovation basis of the firm is summarized in Table 3, and three factors are extracted in the result of factor analysis. Since the first factor consists of “Capability to create new product and service” and “Capability to solve customer's problem” and “Core original technology and R&D capability,” these are singled out as one variable termed as “innovation capability.” As for the second factor which includes “Positively offering other companies your own technology,” “Received technical proposals from the other companies” and “Understanding the strong point of the partner, and collaborating in the field of the strong point each other” are extracted, and the relating variable is referred to as “External linkages.” In the same manner, the third factor which includes of “Ideas of the new product and service often create in the firm,” “Basic research and R&D are coordinated” and “Analyzing data of product and service of your company and the competitor” is extracted, and accordingly it is named as “innovation activity.”

Table 3. Factor analysis of innovation capability and activity

	Innovation Capability and Activity		
	Innovation capability	External linkages	Innovation activity
Capability to create new product and service	0.801	-0.03	0.069
Capability to solve customer's problem	0.679	0.079	-0.129
Core original technology and R&D capability	0.629	-0.045	0.127
Positively offering other companies your own technology	0.073	0.678	-0.049
Received technical proposals from the other companies	-0.076	0.641	-0.028
Understanding the strong point of the partner, and collaborating in the field of the strong point each other	0.03	0.528	0.103
The ideas of the new product and service often create in the firm.	-0.078	-0.017	0.936
Basic research and R&D are coordinated.	-0.011	-0.01	0.878
R&D is directly connected to new product and service	0.211	-0.061	0.514
Analyzing data of product and service of your company and the competitor	0.026	0.277	0.445
Factor Correlation Matrix			
1	0.612	0.446	1
2	1	0.21	0.612
3	0.21	1	0.446
Cronbach's α	0.757	0.69	0.822

Source: Authors

One factor is extracted in the result of factor analysis regarding the effect of ICT (Table 4). Since the factor consists of “Usefulness of PR for goods,” “Speed improvement of managerial judgment and business development,” “Shortening of product at development period,” “Increasing in number of new product and service development,” and “Easiness of awareness of customer's needs,” the variable is termed as “Effect of ICT.”

Table 4. Factor analysis of the effect of ICT

	Effect of ICT
Usefulness of PR for goods	.878
Speed improvement of managerial judgment and business development	.872
Shortening of product at development period	.685
Increasing in number of new product and service development	.681
Easiness of awareness of customer's needs	.566
Cronbach's α	.852

Source: Authors

In Table 5, latent variables and observable variables to analyze two models are summarized.

Table 5. Variables for Covariance Structure Analysis

	Latent variables	Observable variables
	Innovation	Presence of product innovation Presence of process innovation
Human factor	Top management's participation	The top manager voluntarily shows the idea and decides a new business. The top manager takes leading to do new business.
	Employee's motivation	The employee understands the target of the firm. The employee is proud of his/her firm. The employee understands the strong point of the firm. There is atmosphere that consults the colleague easily. The employee understands the scene for which the in-house product is used. Even if it is unrelated to him/her, the employee helps the others' work.
Innovation basis	Innovation capability	Capability to create new product and service Capability to solve customer's problem Core original technology and R&D capability
	External linkages	Positively offering other companies your own technology Received technical proposals from the other companies Understanding the strong point of the partner, and collaborating in the field of the strong point each other Analyzing data of product and service of your company and the competitor
	Innovation activity	The ideas of the new product and service often create in the firm. Basic research and R&D are coordinated. R&D is directly connected to new product and service Analyzing data of product and service of your company and the competitor
ICT use	Effect of ICT	Usefulness of PR for goods Speed improvement of managerial judgment and business development Shortening of product at development period Increasing in number of new product and service development Easiness of awareness of customer's needs

Source: Authors

3.3 Hypothesis

In this paper, two models of the causal relationship between three sources and innovation are presented and seven hypotheses are attempted to verify. The difference in two models lies in examining the causal relationships among three key sources and innovation, namely one model postulates that ICT use promotes innovation capability and attracts external linkages, while another model hypnotizes the reverse relationship,

that is, external linkages promote ICT use. This paper analyzes which model is suitable by using the Covariance Structure Analysis. In order to make discussion clear, the causal relationships among key variables such as three sources are categorized into four groups, and hypotheses are presented in each group.

(1) Human factor

The hypotheses of the first group are related to human factors, which are represented by top management's participation and employee's motivation in this paper. Top management takes the leadership in the business management in general, which includes positive activities to promote innovation capability, to collaborate with external linkages, and to introduce ICT. In addition to top management, employees are engaged in actual activities to achieve the objectives, and then their motivation and business ethics are also essential. Therefore, causal relationships between these two human factors and three sources are presented as follows:

H1: Top management's participation and employee's motivation promote ICT use.

H2: Top management's participation and employee's motivation improve the innovation capability.

H3: Top management's participation and employee's motivation promote external linkages.

There is no need to mention about rationale of these hypotheses. Regarding H1, Damaskopoulos and Evgeniou (2003) and Cragg and Zinatelli (1995), for example, emphasize the importance of top management's participation in the adoption of ICT, while Caroli and van Reenen (2001) emphasize workers motivation for ICT adoption. As for H2, Tidd, et al. (2001) lists up top management's participation and employee's motivation as important factors in constructing innovative organization by claiming that the former has to have shared vision, leadership and the will to innovation.

(2) Causality among three sources

The following two hypotheses are related to the causal relationship among three sources of innovation, which are main research question of this paper:

H4_1: ICT use promotes the innovation capability and external linkage.

H4_2: The innovation capability and external linkage promote ICT use.

The hypotheses examine whether ICT use is cause or result of innovation capability

and external linkages. There are different results regarding these hypotheses, namely Chen (2012) showed that IT-enabled resources have impact on R&D capability, whereas Park et al. (2012) showed that ICT causes innovation via organizational capability. Hollenstein (2004), Carlsoon (2004), and Becchetti et al. (2003) showed ICT use enhance only product innovation.

(3) Resources and innovation activity

This hypothesis is related to how sources affect innovation activity, which is a variable constructed by the following questions in the questionnaire.

H5: The innovation capability, external linkage and ICT use promote the innovation activity.

Among previous studies, Chen (2012) shows that ICT promotes innovation capability and then capability enhances financial performance via his “Strategic objectives.” This paper also intends to show the same process, but here “Strategic objectives” is the same concept of our “innovation activity.”

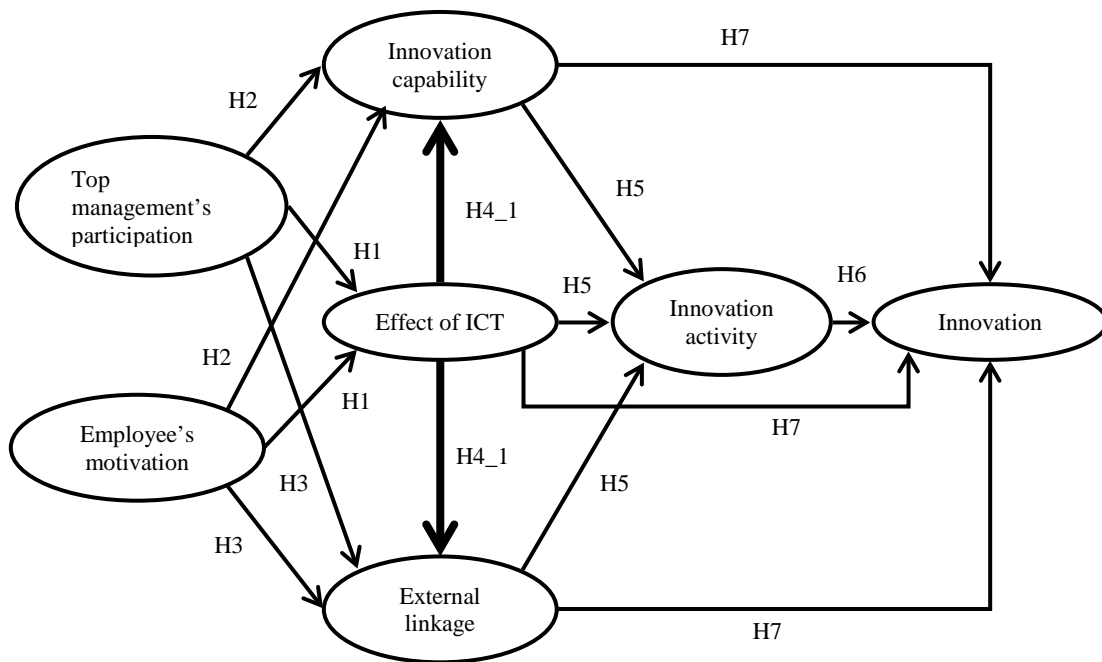
(4) Sources and innovation

This hypothesizes the final causality between sources and innovation.

H6: The innovation activity promotes the innovation.

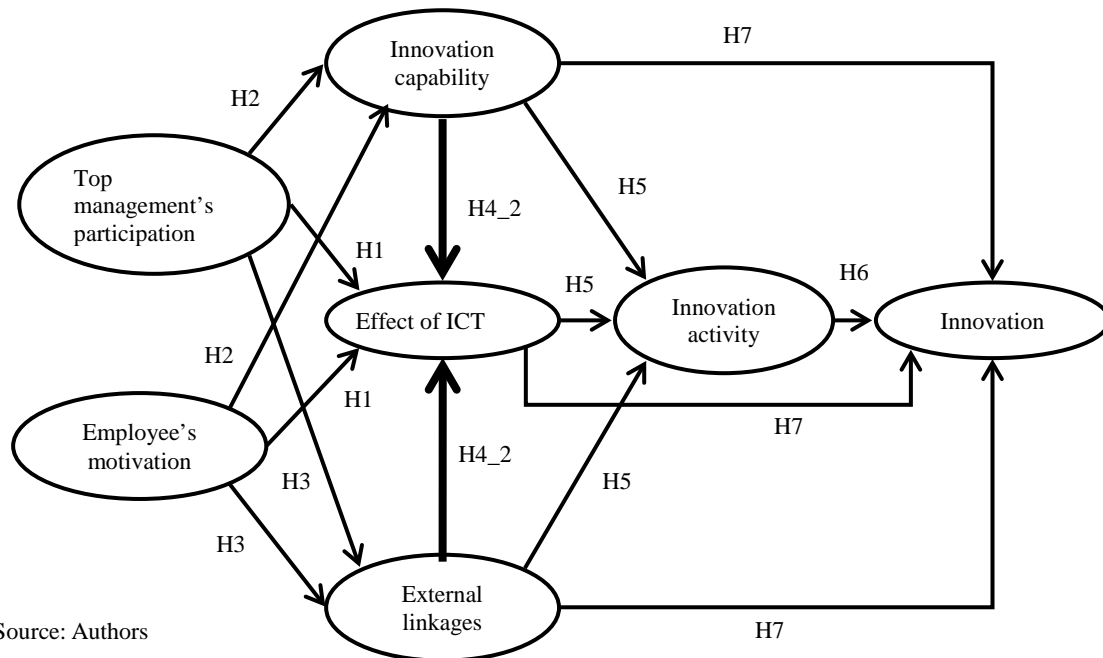
H7: The innovation capability, external linkage and ICT use directly promote the innovation.

In order examine above hypotheses, this paper presents two models which are depicted in the following Figure 1 and 2, and the hypotheses are summarized in Table 6 and 7. The difference between two models lies in whether “Effect of ICT use” is cause or result of “Innovation capability” and “external linkages.”



Source: Authors

Figure 1. Model 1: “Effect of ICT” is a cause to “Innovation capability” and “External linkages”



Source: Authors

Figure 2. Model 2: “Effect of ICT” as a result of “Innovation capability” and “External linkages”

Table 6. Hypotheses of Model 1

Phase	No.	Hypothesis
I	H1	Top management's participation and employee's motivation promote ICT use.
	H2	Top management's participation and employee's motivation improve the innovation capability.
	H3	Top management's participation and employee's motivation promote external linkage.
II	H4_1	ICT use promotes the innovation capability and external linkage.
III	H5	The innovation capability, external linkage and ICT use promote the innovation activity.
IV	H6	The innovation activity promotes the innovation.
	H7	The innovation capability, external linkage and ICT use directly promote the innovation.

Source: Authors

Table 7. Hypotheses of Model 2 (difference from Model 1)

Phase	No.	Hypothesis
II	H4_2	The innovation capability and external linkage promote ICT use.

Source: Authors

4. Result of Analysis

4.1 Selection of the model

Table 8 and 9 indicate the fitness of two models of Covariance Structure Analysis. GFI (Goodness of Fit Index) and AGFI (Adjusted Goodness of Fit Index) take the value between 0 and 1, which indicate criteria of the explanatory power of the model. If $GFI \geq AGFI$ and both indices are 0.9 or more, the model can be judged as proper. CFI (Comparative Fit Index) evaluates the model in terms of goodness-of-fit, which indicates how much the model is improved in comparison with the independent model estimated under the assumption that there is no correlation among the observed variables. It takes the value from 0 to 1, and the model is judged as being good fit if CFI is 0.9 or more. Moreover, RMSEA (Root Mean Square Error of Approximation) is an index that expresses the divergence between the estimated and actual distribution of the model expressed in terms of the amount a degree of freedom. The model can be judged as good fitness, if it is 0.05 or less. The values of those indices in both models are almost the same and take the values such as GFI ($0.920 \geq 0.9$), AGFI ($0.900 \geq 0.9$), CFI ($0.945 \geq 0.9$), RMSEA ($0.045 \leq 0.05$). Thus these tests can show that the goodness-of-fit of two models is high.

Next, which model is selected is determined according to AIC. When two or more

models are compared, AIC (Akaike Information Criterion) becomes an index to evaluate relative goodness of the model. The best model is selected if it has the lowest AIC. Since AIC value of Model 1 (AIC=636.210) is lower than that of Model 2 (AIC=637.822), Model 1 is adopted, that is, “Effect of ICT” is cause of “Innovation capability” and “External linkages”.

Table 8. Model 1: “ICT” affects to “Innovation capability” and “External linkages” for “Innovation”

χ^2 value	Degree of freedom	p value	GFI	AGFI	CFI	RMSEA	AIC
503.822	258	0.000	0.920	0.900	0.945	0.045	636.210

Source: Authors

Table 9. Model 2: “Innovation capability” and “External linkages affect “ICT” for Innovation

χ^2 value	Degree of freedom	p value	GFI	AGFI	CFI	RMSEA	AIC
503.822	258	0.000	0.920	0.900	0.945	0.045	637.822

Source: Authors

4.2 Direct and indirect effect to innovation

Here the concrete amounts of effect of factors to innovation are discussed. The estimated method of Covariance Structure Analysis can calculate the following three effects separately by using software “AMOS”: (i) the standardizing total effects (Table 10); (ii) direct effect (Table 11); and (iii) indirect effect (Table 12). First, Table 10 shows effects termed by the standardizing total effects implying that the direct effect and the indirect effect are added together. Table 11 shows the standardizing the direct effect, which indicates effect from one variable to another variable. Table 12 indicates the standardizing indirect effect, which implies the effect of a variable to another via related variable(s). It should be noted that Software “AMOS” cannot calculate the indirect effect of individual path, but total of all related paths.

In order to see the effect more clearly, let take an example of innovation capability and examine its effect to innovation. Table 10 shows that its standardizing total effect to innovation, which amounts to 0.345. This effect is decomposed into the direct and indirect effect. Table 11 shows its direct effect to innovation, which amounts to 0.171, while its indirect effect to innovation shown in Table 12 amounts to 0.173. As the result, the total effect amounts to 0.345. Innovation capability thus promotes directly and indirectly innovation, but the indirect effect is larger than direct.

Next, let discuss effect of ICT to innovation. The standardizing total effects amount to 0.384 (Table 10), which is the largest among other factors listed in the table. This amount can be decomposed into direct and indirect effects; the mount of the former is 0.185 (Table 11), while its indirect effect via innovation activity is 0.199 (Table 12). It should be noticed that the indirect effect is larger than the direct effect.

In sum, it is also shown that the factor which owns the largest effect to innovation is the effect of ICT use. The amounts of all effects are summarized in Figure 3.

Table 10. Standardizing total effects

To \ From	Top management's participation	Employee's motivation	Innovation capability	External linkages	Effect of ICT	Innovation activity
Effect of ICT	0.239	0.191	0	0	0	0
Innovation capability	0.301	0.449	0	0	0.245	0
External linkages	0.231	0.223	0	0	0.363	0
Innovation activity	0.25	0.317	0.516	0.253	0.37	0
Innovation	0.201	0.239	0.345	0.176	0.384	0.336

Source: Authors

Table 11. Standardizing direct effects

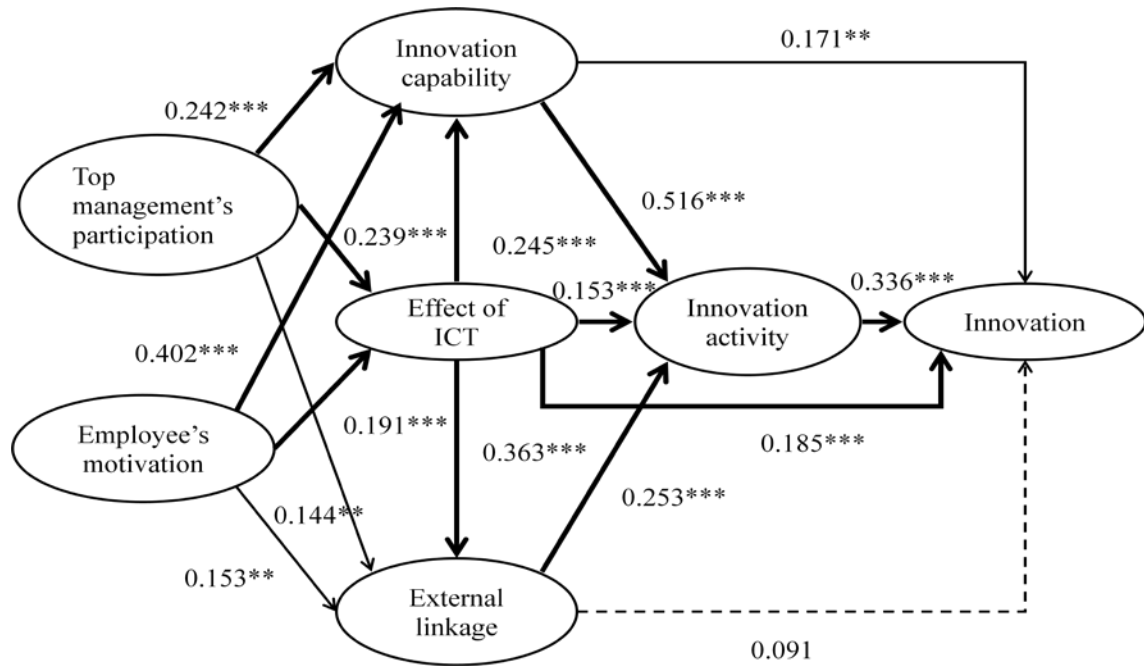
To \ From	Top management's participation	Employee's motivation	Innovation capability	External linkages	Effect of ICT	Innovation activity
Effect of ICT	0.239	0.191	0	0	0	0
Innovation capability	0.242	0.402	0	0	0.245	0
External linkages	0.144	0.153	0	0	0.363	0
Innovation activity	0	0	0.516	0.253	0.153	0
Innovation	0	0	0.171	0.091	0.185	0.336

Source: Authors

Table 12. Standardizing indirect effects

To \ From	Top management's participation	Employee's motivation	Innovation capability	External linkages	Effect of ICT	Innovation activity
Effect of ICT	0	0	0	0	0	0
Innovation capability	0.059	0.047	0	0	0	0
External linkage	0.087	0.069	0	0	0	0
Innovation activity	0.25	0.317	0	0	0.218	0
Innovation	0.201	0.239	0.173	0.085	0.199	0

Source: Authors



Notes: thin line shows significant at 5%; thick line shows significant at 1%; dashed line shows no significant.

Source: Authors

Figure 3: Summary of Results

4.3 Verification of hypotheses

As mentioned above, Model 1 is selected, and in what follows, all discussions are based on Model 1. Table 13 summarizes the estimation results related to H1-H7, and let examine hypotheses one by one.

(1) Hypothesis1

The causality from “Top management’s participation” to “effect of ICT” has 0.239 ($p < 0.000$) and the causality from “Employee’s motivation” to “effect of ICT” has 0.191 ($p < 0.000$) and thus these two are positively significant. Therefore, H1 implying “the manager's participation and the employee's motivation promote ICT use” is verified.

(2) Hypothesis2

The causality from “Top Management’s participation” to “Innovation capability” is 0.242 ($p < 0.000$) and that from “Employee’s motivation” to “Innovation capability” is 0.402 ($p < 0.000$), and these arrows are positively significant. Therefore, H2 implying “top manager's participation” and “employee's motivation” cause to enhance

“innovation capability” is verified.

(3) Hypothesis3

The relationship from “Top Management’s participation” to “External linkages” is 0.144 ($p < 0.016$) and that from “Employee’s motivation” to “External linkages” is 0.153 ($p < 0.012$) and thus both are positively significant. Therefore, H3 implying “Top management's participation” and “Employees’ motivation” promote “External linkages” is verified.

(4) Hypothesis4

The relationship from “Effect of ICT” to “Innovation capability” is 0.245 ($p < 0.000$) and that from “Effect of ICT” to “External linkages” is 0.363 ($p < 0.000$). These are positively significant. Therefore, H4_1 and H4_2 implying “Effect of ICT use” promotes the “Innovation capability” and “External linkages” is verified.

(5) Hypothesis5

The relationship from “Effect of ICT” to “Innovation activity” is 0.516 ($p < 0.000$), that “Innovation capability to innovation activity” is 0.253 ($p < 0.000$), that from “External linkage to innovation activity” is 0.153 ($p < 0.000$) became positively significant. Therefore, H5 implying “Innovation capability,” “External linkages” and “Effect of ICT use” promote “Innovation activity” is verified.

(6) Hypothesis6

The relationship from “Innovation activity” to “innovation” is 0.336 ($p < 0.000$) becomes positively significant. Therefore, H6 implying “Innovation activity” promotes “Innovation” is verified.

(7) Hypothesis7

The relationship from “Effect of ICT” to “Innovation” is 0.171 ($p < 0.044$) and that from “Innovation capability” to “Innovation” is 0.185 ($p < 0.008$) and then it becomes positively significant. However, the causality from “External linkages” to “innovation” is found not significant. Therefore, H7 implying “Innovation capability,” “External linkages,” and “ICT use” directly promote “Innovation” is partly verified.

5. Discussion

This study demonstrates the causal relationship among three innovation sources and that between three sources and innovation. The characteristics of this paper lie in the following two:

(1) Rigorous examination

Regarding relationship between effect of ICT use and sources such as innovation capability, External linkage, two models are constructed and analyzed which one is valid by Covariance Structural Analysis. There are two opposite relationships can be considered between ICT use and innovation capability, namely, ICT enhances innovation capability, or firms with higher innovation capability can easily introduce ICT and promote efficiency. True causality must be analyzed. In doing so, this paper constructs two models with different causality, and showed the ICT use affects innovation capability and external linkages. Chen (2012) shows that IT-enabled resources have an impact on R&D capability, but the reverse relationship is not examined. Park et al. (2012) ICT affects innovation via Organizational capability, but it does not examine another possible relationship, either. It might be the case the reverse relationship is also viable.

Table 13. Result of Covariance Structure Analysis (Model 1)

	From	To	Standardizing Coefficient	SE	Test statistic	<i>p</i> value
H1	Top management's participation	Effect of ICT	0.239	0.043	4.374	0.000***
H1	Employee's motivation	Effect of ICT	0.191	0.087	3.498	0.000***
H2	Top management's participation	Innovation capability	0.242	0.049	4.507	0.000***
H2	Employee's motivation	Innovation capability	0.402	0.11	6.833	0.000***
H3	Top management's participation	External linkages	0.144	0.042	2.408	0.016**
H3	Employee's motivation	External linkages	0.153	0.088	2.51	0.012**
H4_1	Effect of ICT	Innovation capability	0.245	0.062	4.584	0.000***
H4_1	Effect of ICT	External linkages	0.363	0.061	5.38	0.000***
H5	Innovation capability	Innovation activity	0.516	0.053	8.32	0.000***
H5	External linkages	Innovation activity	0.253	0.068	4.08	0.000***
H5	Effect of ICT	Innovation activity	0.153	0.053	2.836	0.005***
H6	Innovation activity	Innovation	0.336	0.044	3.534	0.000***
H7	Innovation capability	Innovation	0.171	0.033	2.015	0.044**
H7	External linkages	Innovation	0.091	0.04	1.141	0.254
H7	Effect of ICT	Innovation	0.185	0.032	2.66	0.008***

Source: Authors

(2) Intermediate parameter

Many studies such as Perdomo-Ortiz et al. (2009), Menguc and Auh (2010), Yam et al. (2011), Kmiecik et al. (2012) and so on, most of which attempt to clarify the direct relationship between capability and managerial performances. But firms with high capability may not necessarily achieve high performances automatically. In contrast, it is natural to consider that in such firms, high capability promotes business behavior and as a result, firms elevate performances. This paper adds a variable such as innovation activity which is an intermediate variable between capability and innovation. Chen (2012) adds “Strategic objective between capability and performances, and Bergh, and Lim (2008) adds “Sell-off” and “Spin-off” as “Restructuring mode.”

6. Conclusion

In this paper, the relationship between ICT use and innovation in Japanese SMEs was analyzed by the covariance structure analysis. As the results of the analyses, the model of “ICT affects innovation capability and external linkages” was selected according to AIC; that is, innovation capability and external linkages are activated by ICT use, and thus innovation is promoted. On the other hand, the model that “ICT use is improved by innovation capability and external linkages, and then innovation is promoted,” was not suitable.

There was a limitation such that data was only Japanese SMEs, though the mechanism that ICT use promoted innovation was clarified in this paper. However, all other coefficients are positively significant according to the adopted model except the hypothesis such that external linkages promote innovation directly. The result indicates the following; (i) top management’s participation and employee’s motivation promote effect of ICT use, innovation capability and external linkage; (ii) effect of ICT use raises innovation capability and external linkages; (iii) effect of ICT use, innovation capability and external linkages activate innovation activity and promote innovation as a result; and (iv) effect of ICT use and innovation capability promote innovation directly. The effect of ICT use is the largest variable which contributes innovation. From this, ICT use is indispensable for innovation in Japanese SMEs.

Note

*The questionnaire survey targeted unlisted innovative SMEs which have the following characteristics: (1) the number of employees is more than 20; (2) the amount of sales is from one million to 9.9 billion yen in the 2011 fiscal year; (3) the latest sales growth rate is more than 20%; and (4) continuous surplus is achieved in the recent three terms.

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