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Idota, Hiroki; Bunno, Teruyuki; Tsuji, Masatsugu

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Empirical Study on ICT Use and Business Strategy for Innovation among Japanese SMEs

By

Hiroki Idota, Teruyuki Bunno, Masatsugu Tsuji

Empirical Study on ICT Use and Business Strategy for Innovation among Japanese SMEs

Hiroki Idota
Faculty of Business Management, Otemon University, Japan
E-mail: idota@res.otemon.ac.jp

Teruyuki Bunno
Faculty of Business Management, Kinki University, Japan

Masatsugu Tsuji
Graduate School of Applied Informatics, University of Hyogo, Japan

Abstract

ICT is expected to play an important role for innovations in Japanese SMEs. In this paper, how ICT use promotes innovation is clarified. In addition, what kind of business strategy SMEs should follow is attempted to achieve innovation by focusing on the behavior of the top management as well as employees. A mail survey was conducted in February 2012 to innovative SMEs. An ICT advancement index is constructed based on the sales management system, groupware, internal SNS and SCM. Logistic regression analysis is applied for verifying the four hypotheses by using the ICT index. The results obtained reveals that SNEs that used ICT for new product development such as collecting customers' needs achieve more product as well as process innovation. And it is confirmed that SMEs which positively share information using ICT achieve more process innovation. And top management should demonstrate the leadership, and manage the product innovation process through top-down including the promotion of ICT use. On the other hand, not only the manager but also the employees have to act flexibly and autonomously to share information by ICT are important in the process innovation that is required to restructure existing business processes.

1. Introduction

Under a long-term recession, without developing continuously new product and service and improving drastically the business process, it is impossible for Japanese SMEs (small and medium-sized enterprises) can survive. In order to achieve this, the further empowerment of SMEs to enhance innovation is required. This is a difficult and time-consuming task. There are many factors behind the promotion of innovation in an economy, as endogenous economic growth theory emphasizes, i.e. capital, labor and technology. In reality, it is difficult to raise these factors and promote economic development in the entire economy, but it is more difficult to improve the power of innovation within individual SMEs which do not own sufficient resources for innovation.

There are many sources for promoting innovation, including technological ability, managerial organization to enhance the flow of information and ideas related to innovation, orientation of top management to create innovation, human resources such as engineers, and workers at the job shop. Moreover, since SMEs do not own sufficient resources for innovation inside the firms, they have to absorb the necessary technology and information from outside such as large firms, universities, regional research institutions, and business organizations. SMEs thus have to obtain and mobilize these factors and resources from outside as well as inside SMEs and assimilate them into innovation. In order to achieve innovation, current SMEs have a more advantage than those in the past, that is, Information and Communication Technology (ICT). In the age of the information society, SMEs can make full use of ICT to achieve innovation (Lee & Xia, 2006). ICT can contribute to promote innovation by the following ways: (1) obtaining related information from outside via the transaction networks with customers and suppliers or via research networks with regional research institutions and universities; and (2) sharing information with workers by constructing information networks using PCs or SNS. It is important to examine how ICT promotes innovation. Simply introducing PCs does not automatically create innovation, but it

is more important how SMEs use PCs to promote innovation. In this context, this paper focuses on the process or transmission mechanism how ICT contributes to innovation. There is no room for doubt that ICT shows fully its power to collecting and share information among all entities of the firm.

Our previous papers examined the relationship between SMEs' ICT use and innovation (Idota, et al., 2010; 2011; and 2012a) showed the following results: (1) innovative SMEs used ICT for product as well as process innovation; (2) what kind of ICT use was useful for innovation activities; and (3) success factors of ICT introduction for innovation activity such as business culture of firms, business organization, and leadership of top management. Another previous paper (Idota, et al, 2012b) showed that the sales management system, CRM and SNS were found to be significant for product innovation, and in particular, the information systems developed in cooperation with ICT coordinators, consultants, the parent company, group companies and customers were significant as success factors for product innovation. On the other hand, the manufacturing management system such as CAD, CAM, and the Internet were significant for process innovation. In particular, the information systems developed in cooperation with customers and exchanging information with customers became significant for process innovation.

Idota, et al. (2011) also showed that internal social media promoted product innovation. Especially, internal social media had effect on the speed of information exchange among employees and time until knowledge is ready to work.

This paper aims to focus on (1) the current situation of SMEs' ICT use for innovation, and (2) whether those ICT uses contribute to achieving innovation. Regarding the former, this paper attempts to construct a simple index which is a proxy of ICT use of SMEs. In other words, this paper aims to construct an index from various factors related to creating innovation. Using this index, the latter problem will be analyzed by regression analysis, namely whether the index is significantly related to innovation. In addition, the transmission channels which connect ICT use and innovation will be identified.

2. Hypotheses

In order to achieve the aims of this paper, the following hypotheses are constructed from our previous research.

Hypothesis 1: Firms more advancing ICT use create more innovation

ICT was viewed as effective tools for innovation (Lee & Xia, 2006). Therefore, it is assumed the higher level of ICT use is, the more useful for the innovation.

Hypothesis 2: An increase in R&D expenditures and recruiting mid-career employees is necessary for innovation

Innovation is a product of innovative ideas, and innovative ideas are created by human resources and enough research funds. R&D expenditures, for example, are bases to create new ideas, new technologies, new products and services. Innovative ideas are created by human resources. They are the least sufficient in SMEs. It is essential for SMEs to solve the problem of these limited resources for innovation. SMEs do not have enough funds to nurture young employees to be innovation experts, although they have life-time employment system which firm provides enough on-the-job training to educate employees. In addition to in-house training, SMEs have to recruit constantly mid-career employees with enough experience. Therefore, R&D expenditures and recruiting mid-career employees are assumed to be necessary for innovation.

Hypothesis 3: The top management's participation and employee's morale are important for the innovation

Top management and employee are two wheels to promote innovation, and they are essential for innovation. Without the suitable leadership, the innovation process is not well directed. Top manager's voluntarily taking the initiative and participating in the project are important factors.

Japanese firms are famous for "*Kaizen* (improvement activity)" at the production site or job shop. Quality management (quality control) is a typical example. Voluntary participation of improvement is one index showing employee's moral for innovation.

Hypothesis 4: The effect of ICT on sharing information and developing new product promotes innovation.

ICT has various effects such as improving efficiency in the business process, decision support, and communications, and so on. Collecting customers' needs, activating the communications among workers and sharing information and knowledge are useful for innovation. Hence, it is assumed that the effects of sharing information by ICT and concerning the new product development promote innovation.

In what follows, we analyze whether the above four hypotheses will be held.

3. Research Method

This paper is based on the mail survey conducted in February 2012 to 3, 959 innovative Japanese SMEs in the industries including manufacturing, service, information processing service and construction[1)]. 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, ICT use, merit of ICT, and so on. The index of ICT use was constructed using this data, which will be explained in the paper. The aim of the analysis is to verify whether the above four hypotheses are held or not.

3.1. Basic Statistics

In this section, the profile of respondents will be presented. Regarding the industry, 357 firms (56%) belong to manufacturing, 184 (29%) to construction, 53 (8%) to information, 38 (6%) to the service industry, and 14 (2%) to others (Table 1). As for the period of operation, 30-49 years of operation is 219 (35.0%), which is the largest. And it is concentrated on 10-70 years (Table 2). As for capital, less than 10 million yen is 170 (26.6%), which is the largest (Table 3). And the number of full time employees are concentrated on less than 50 (Table 4). Therefore, a lot of companies are small. 539 companies (83.3%) recruited mid-career employees in the recent three years (Table 1).

In R&D expenditures in the recent three years, "leveling off" is 251 (57.3%), which is the largest. And 131 (29.9%) replied "increase," which is the next largest (Table 5).

Table 1. Basic statistics

Variable	Freq.	Mean	Std. Dev.	Min	Max
The period of operation (Logarithm)	626	3.56	0.67	0.00	5.06
Capital (Logarithm)	638	7.85	1.02	2.30	11.14
Number of mid-career hiring employees for recent three years	539	6.64	9.53	0.00	100.00
Manufacturing	640	0.56	0.50	0.00	1.00
Information	640	0.08	0.28	0.00	1.00
Service	640	0.06	0.24	0.00	1.00
Construction	639	0.29	0.45	0.00	1.00
other industry	640	0.02	0.15	0.00	1.00
Increase or decrease of R&D expense for recent three years	438	2.17	0.63	1.00	3.00

Source: Authors

Table 2. Years of operation

the period of operation	Freq.	%
Less than 10 year	36	5.8
10-30 year	170	27.2
30-49 year	219	35.0
50-69 year	140	22.4
70-99 year	49	7.8
More than 100 year	12	1.9
Total	626	100.0

Source: Authors

Table 3. Capital

Capital	Freq.	%
Less than10 million yen	170	26.6%
10-15 million yen	23	3.6%
15-20 million yen	92	14.4%
20-25 million yen	35	5.5%
25-30 million yen	80	12.5%
30-40 million yen	52	8.2%
40-50 million yen	67	10.5%
50-100 million yen	86	13.5%
More than 100 million yen	33	5.2%
Total	638	100.0%

Source: Authors

Table 4. The number of full time Employees

Full time employees	Freq.	%
1-20	78	12.6%
21-30	176	28.3%
31-40	111	17.9%
41-50	81	13.0%
51-60	41	6.6%
61-70	26	4.2%
71-80	29	4.7%
81-90	12	1.9%
91-100	14	2.3%
101-200	43	6.9%
201-300	8	1.3%
301-600	2	0.3%
Total	621	100.0%

Source: Authors

Table 5. Increase or decrease in R&D expenditures in the recent three years

Increase or decrease of R&D expense for recent three years	Freq.	%
Decrease in R&D expenditures	56	12.8
Leveling off R&D expenditures	251	57.3
Increase in R&D expenditures	131	29.9

Source: Authors

Innovation is categorized by types such as "product innovations" which associates with the creation of new products and services, and "process innovations" with increasing productivity and efficiency of business works. Regarding the achievement of innovation for recent five years, 428 (67.2%) replied they achieved product innovation, while 308 (48.9%) process innovation (Table 6).

Table 6. Achieving innovation in the recent five years

Variable	Freq.	%	Std. Dev.
Product innovation	428	67.2%	0.47
Process innovation	308	48.9%	0.50

Source: Authors

Table 7 shows question related to the types of ICT use. The most common use of ICT is e-mail (84.5%), while the lowest is SCM (2.7%). ICT systems such as design management system, product management, and sales management are connected to SMEs' missions and the mostly widespread. Groupware and internal SNS for sharing information inside SMEs are also widely used, while SCM and general SNS for connecting with outside firm or customer is not widespread. One of the aims of this paper is to construct an index of ICT use. In so doing, four types of ICT use such (1) the sales management system, (2) groupware, (3) internal SNS, and (4) SCM are focused.

The sales management system is ICT which fulfills the basic mission and it should be prepared by all industries. As for product innovation, demand and needs of customer can be obtained by the above system. Process innovation improves routine works related to core business management in a single firm. Therefore, the sales management system is useful for process innovation.

Groupware and internal SNS are important ICT for sharing information among workers inside firm. The functions of this type of ICTs tend to be integrated by using the Internet technology in the recent years. Therefore, these functions should be considered consistently and uniformly. Sharing information inside firm is important for making new product and services and improving business process. Groupware and internal SNS can be used for product innovation and process innovation.

SCM is indispensable to construct the network with outside firms. Process innovation, improves efficiency of routine works related to core business management among firms in the network. Process innovation is aimed to raise customer satisfaction and to enhance customer's values continuously (Tohoyama, 2003). In the process, the firm communicates and collaborates with outside firm. SCM becomes an important tool for collecting customer needs for improving supply chain process. And customer needs are contributed for product innovation, which is making new product and service.

Table 7 indicates that the sales management system is already adopted by 322 (37.4%) SMEs, groupware by 139 (22.4%), internal SNS by 81(13.0%), and SCM by 17 (2.7%). Regarding the construction of the index, point is provided according to importance of these ICT use, that is, ICT more commonly used indicates that it is rather easy for SMEs to adopt it, and therefore it obtains a small point. We provide one point for ICT which use exceeds 30% of respondents. ICT use with the diffusion rate of 10-30% has two points, while ICT with less than 10% diffusion rate owns three points. Since one SME may have several type of ICT uses, all indices are added in order to calculate the maturity level of ICT for each SME. The

final distribution of point is shown in Table 8 and Figure 1, which is varying from 0 to eight points

3.2. Factor analysis

The questionnaire has many questions which ask SMEs' managerial behavior and ICT use, etc. Hence, it is necessary to specify potential variables, which are referred to as "factors" in what follows. In so doing, it is necessary to identify potential variables which influence observed variables based on the correlation that commonly exists behind the relationship and influence the observation variables, and for this purpose factor analysis is applied. Table 9 indicates management behavior of top management and employees. These questions are answered in the Likert five scale. The averages of all questions are over 3.5 point. These are very high.

Table 7. ICT use

Variable	Freq.	%	Std. Dev.
Sales management system	232	37.4	0.48
Product management system	260	41.9	0.49
Design management system	376	60.5	0.49
ERP(Enterprise Resource Planning)	36	5.8	0.23
Groupware	139	22.4	0.42
CTI (Computer Telephony Integration)	19	3.1	0.17
SCM (Supply Chain Management)	17	2.7	0.16
e-mail	525	84.5	0.36
Internal SNS (Social Networking Service)	81	13.0	0.34
General SNS (Social Networking Service)	30	4.8%	0.21

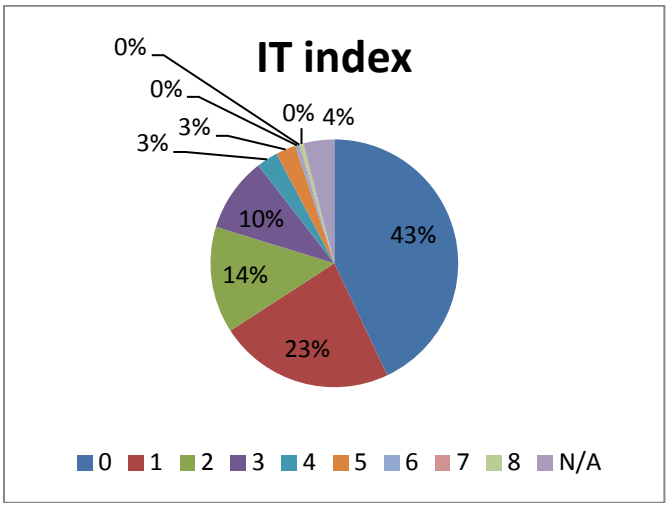
Source: Authors

To specify these factors, factor analysis is conducted by maximum likelihood the method (Varimax Rotation). The result is shown in Table 10, in which two factors are extracted. 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' morale" 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 8. ICT index

ICT index	Freq.	%
0 point	278	43.0%
1 point	148	22.9%
2 point	90	13.9%
3 point	63	9.7%
4 point	18	2.8%
5 point	17	2.6%
6 point	3	0.5%
7 point	1	0.2%
8 point	3	0.5%
N/A	26	4.0%
Total	647	100.0%

Source: Authors



Source: Authors

Figure 1. ICT index

Table 9. Management behavior

Variables	Freq.	Mean	Std. Dev.	Min	Max
The top manager voluntarily shows the idea and decides a new business.	641	3.71	0.99	1	5
The top manager takes leading to do new business.	641	3.89	0.96	1	5
The top manager positively participates in the project.	609	3.81	1.15	1	5
The employee understands the target of the firm.	644	3.97	0.73	1	5
The employee is proud of his/her firm.	644	3.84	0.71	1	5
The employee understands the strong point of the firm.	644	3.93	0.68	2	5
There is atmosphere that consults the colleague easily.	641	3.78	0.77	1	5
The employee understands the scene for which the in-house product is used.	639	3.91	0.84	1	5
Even if it is unrelated to him/her, the employee helps the others' work.	641	3.65	0.81	1	5

Source: Authors

Table 10. Factor analysis of managerial behavior

Management behavior	Common factors	
	the employees' concern	the top manager's participation
The employee is proud of his/her firm.	.751	.068
The employee understands the strong point of the firm.	.724	.095
The employee understands the target of the firm.	.696	.113
Even if it is unrelated to him/her, the employee helps the others' work.	.616	.011
There is atmosphere that consults the colleague easily.	.613	.050
The employee understands the scene for which the in-house product is used.	.523	.108
The top manager takes leading to do new business.	.023	.907
The top manager voluntarily shows the idea and decides a new business.	-.003	.827
The top manager positively participates in the project.	.258	.398
Eigen Value	2.668	1.706
Rotated Factor Pattern (%)	29.641	18.959
Cumulative Proportion (%)	48.601	
Cronbach's α	.817	.720

Source: Authors

Table 11 shows the effects of ICT use. These questions are answered in the Likert five scale in the same way as the previous case. "Sharing information and knowledge in the firm" has 3.66 point, and "Activation of communications with customer" 3.52 point on the average. Thus, they have high point, and averages of all questions have larger than 2.8 point.

To specify factors, factor analysis is conducted again by the same maximum likelihood method. The result is shown in Table 12. Two common factors were extracted, namely the first factor contains "Sharing information and knowledge in the firm" and "Activation of communications," which is termed by as "Sharing information by ICT use." Since the second factor consists of "Shortening the product development period," "Easiness of awareness of customer's needs," and "Usefulness of PR for goods," which is termed as "Developing new product by ICT use."

Table 11. Effects of ICT use

Variables	Freq.	Mean	Std. Dev.	Min	Max
Shortening of product at development period	601	2.83	1.13	1	5
Usefulness of PR for goods	612	3.14	1.26	1	5
Easiness of awareness of customer's needs	608	3.16	1.07	1	5
Activation of communications in in-house	611	3.29	1.09	1	5
Activation of communications with customer	613	3.52	1.00	1	5
Sharing information and knowledge in in-house	609	3.66	1.00	1	5
Sharing information and knowledge with customer	612	3.39	0.93	1	5

Source: Authors

3.3. Result of analysis

In what follows, to verify four hypotheses, logit regression analysis was conducted. "The presence of innovation" is used for the dependent variable, while the explanatory variables contain ICT index, business resources, management behavior and effect of ICT use.

Table 12. Factor analysis on the effect of ICT use

Effects of ICT use	Common factors	
	sharing information	developing new product
Sharing information and knowledge with customer	.804	.254
Sharing information and knowledge in in-house	.735	.219
Activation of communications with customer	.725	.313
Activation of communications in in-house	.626	.332
Shortening of product at development period	.245	.745
Easiness of awareness of customer's needs	.417	.590
Usefulness of PR for goods	.174	.570
Eigen Value	2.368	1.549
Rotated Factor Pattern (%)	33.828	22.130
Cumulative Proportion (%)	55.957	
Cronbach's α	.858	.719

Source: Authors

3.3.1. Relationship ICT index and innovation

"The presence of product innovation and process innovation" are taken as dependent variables and "the period of operation (logarithm)," "capital (logarithm)," "type of industry dummy," and "ICT index" are taken as explanatory variables for logit regression analysis. As a result, in product innovation, "capital (logarithm)" (p-value<0.02) and "ICT index" (p<0.00) became positively significant (Table 13). "Construction" (p<0.03) became negatively significant. Otherwise, in process innovation, "ICT index" (p< 0.00) became positively significant (Table 14).

From these results, it follows that Hypothesis 1 was verified for both product innovation and process innovation.

Table 13. Relationship between ICT index and product innovation

		Number	Of	Obs	=	601
			LR	chi2(7)	=	78.06
		Prob	>	chi2	=	0
			Log	likelihood	=	-341.16209
			Pseudo	R2	=	0.1027
product innovation	Coefficient	Std. Err.	Z-value	P-value		Marginal Effect
The period of operation (Logarithm)	-0.235	0.156	-1.51	0.13		-0.045
Capital (Logarithm)	0.231	0.098	2.36	0.02	**	0.044
Manufacturing	0.149	0.650	0.23	0.82		0.029
Information	0.127	0.723	0.18	0.86		0.024
Service	0.331	0.744	0.44	0.66		0.063
Construction	-1.178	0.650	-1.81	0.07	*	-0.226
ICT index	0.242	0.079	3.08	0.00	***	0.046
Constant	-0.234	1.106	-0.21	0.83		

Notes: * significant at 10%; ** significant at 5%; *** significant at 1%
Source: Authors

Table 14. Relationship between ICT index and process innovation

		Number	Of	Obs	=	593
			LR	chi2(7)	=	38.97
		Prob	>	chi2	=	0
			Log	likelihood	=	-391.50868
			Pseudo	R2	=	0.0474
process innovation	Coefficient	Std. Err.	Z-value	P-value		Marginal Effect
The period of operation (Logarithm)	-0.077	0.138	-0.55	0.58		-0.018
Capital (Logarithm)	0.054	0.086	0.62	0.53		0.013
Manufacturing	0.254	0.577	0.44	0.66		0.059
Information	-0.299	0.638	-0.47	0.64		-0.070
Service	0.447	0.643	0.69	0.49		0.105
Construction	-0.467	0.585	-0.80	0.42		-0.109
ICT index	0.270	0.068	3.99	0.00	***	0.063
Constant	-0.509	0.988	-0.51	0.61		

Notes: * significant at 10%; ** significant at 5%; *** significant at 1%
Source: Authors

3.3.2. Relationship between management resources and innovation

Next, "Number of mid-career employees recruited in the recent three years" and "Increase or decrease in R&D expenditures in the recent three years" were added to the explanatory variables in the previous analysis. Logit regression analysis was conducted. As a result, in addition to "capital (logarithm)" ($p<0.00$) and "ICT index" ($p<0.08$), "Number of mid-career employees recruited in the recent three years" ($p<0.01$) and "Increase or decrease in R&D expenditures in the recent three years" ($p<0.00$) became positively significant in the case of product innovation (Table 15). "Construction" ($p< 0.03$) became also negatively significant. On the other hand, in addition to "ICT index" ($p<0.00$), "Number of mid-career employees recruited in the recent three years" ($p<0.03$) and "Increase or decrease in R&D expenditures in the recent three years" ($p<0.00$) became positively significant in the case of process innovation (Table 16).

These results show Hypothesis 2 is clarified as valid for about both product and process innovation.

3.3.3. Relationship management behavior and innovation

Next, "Employees' concern" and "Top management's participation" as management behavior were added to the explanatory variables in the models shown in the previous 3.3.2. Logit regression analysis was conducted. In addition to "capital (logarithm)"($p<0.00$), "ICT index"($p<0.09$), "Number of mid-career employees recruited in the recent three years" ($p<0.02$) and "Increase or decrease in R&D expenditures in the recent three years" ($p<0.00$), "top manager's participation" ($p<0.00$) became positively significant in case of product innovation (Table 17). "Construction" ($p<0.08$) became negatively significant. In process innovation, in addition to "ICT index"($p<0.01$), "Number of mid-career employees recruited in the recent three years" ($p< 0.07$) and "Increase or decrease in R&D expenditures in the recent three years" ($p<0.00$), "Employees' concern" ($p<0.01$) and "Top manager's participation" ($p<0.02$) became positively significant (Table 18).

Based on these discussions, Hypothesis 3 is verified in case of process innovation, while although "Top manager's participation" is verified in case of product innovation, "employees' concern" is denied.

Table 15. Relationship between managerial resources and product innovation

		Number	Of	Obs	=	362
			LR	chi2(9)	=	69.76
		Prob	>	chi2	=	0
			Log	Likelihood	=	-172.43933
			Pseudo	R2	=	0.1682
product innovation	Coefficient	Std. Err.	Z-value	P-value		Marginal Effect
The period of operation (Logarithm)	-0.199	0.244	-0.81	0.42		-0.031
Capital (Logarithm)	0.490	0.165	2.97	0.00	***	0.077
Number of mid-career hiring employees for recent three years	0.077	0.030	2.56	0.01	**	0.012
Manufacturing	-1.021	1.305	-0.78	0.43		-0.160
Information	-0.828	1.407	-0.59	0.56		-0.130
Service	-1.027	1.308	-0.79	0.43		-0.161
Construction	-2.104	1.316	-1.60	0.11		-0.330
ICT index	0.179	0.102	1.76	0.08	*	0.028
Increase or decrease of R&D expense for recent three years	0.858	0.236	3.64	0.00	***	0.135
Constant	-3.233	1.973	-1.64	0.10		

Notes: * significant at 10%; ** significant at 5%; *** significant at 1%
Source: Authors

Table 16. Relationship between managerial resources and process innovation

		Number	Of	Obs	=	359
			LR	chi2(9)	=	41.72
		Prob	>	chi2	=	0
			Log	Likelihood	=	-225.15322
			Pseudo	R2	=	0.0848
process innovation	Coefficient	Std. Err.	Z-value	P-value		Marginal Effect
The period of operation (Logarithm)	-0.231	0.200	-1.16	0.25		-0.051
Capital (Logarithm)	-0.077	0.126	-0.61	0.54		-0.017
Number of mid-career hiring employees for recent three years	0.030	0.014	2.12	0.03	**	0.007
Manufacturing	1.431	1.000	1.43	0.15		0.313
Information	0.459	1.056	0.44	0.66		0.101
Service	1.391	1.079	1.29	0.20		0.305
Construction	1.154	1.013	1.14	0.26		0.253
ICT index	0.248	0.084	2.94	0.00	***	0.054
Increase or decrease of R&D expense for recent three years	0.688	0.191	3.60	0.00	***	0.151
Constant	-1.612	1.645	-0.98	0.33		

Notes: * significant at 10%; ** significant at 5%; *** significant at 1%
Source: Authors

Table 17. Relationship management behavior and product innovation

		Number	Of	Obs	=	349
			LR	chi2(11)	=	103.37
		Prob	>	chi2	=	0
			Log	Likelihood	=	-145.38888
			Pseudo	R2	=	0.2623
product innovation	Coefficient	Std. Err.	Z-value	P-value		Marginal Effect
The period of operation (Logarithm)	-0.045	0.270	-0.17	0.87		-0.006
Capital (Logarithm)	0.600	0.185	3.25	0.00	***	0.081
Number of mid-career hiring employees for recent three years	0.079	0.033	2.36	0.02	**	0.011
Manufacturing	-1.536	1.471	-1.04	0.30		-0.206
Information	-0.733	1.505	-0.49	0.63		-0.098
Service	-1.288	1.451	-0.89	0.38		-0.173
Construction	-2.570	1.471	-1.75	0.08	*	-0.345
ICT index	0.190	0.112	1.71	0.09	*	0.026
Increase or decrease of R&D expense for recent three years	0.940	0.256	3.67	0.00	***	0.126
The employees' concern	0.102	0.161	0.63	0.53		0.014
The top manager's participation	0.908	0.185	4.92	0.00	***	0.122
Constant	-4.185	2.212	-1.89	0.06	*	

Notes: * significant at 10%; ** significant at 5%; *** significant at 1%
Source: Authors

Table 18. Relationship management behavior and process innovation

		Number	Of	Obs	=	347
			LR	chi2(11)	=	53.3
		Prob	>	chi2	=	0
			Log	Likelihood	=	-210.68131
			Pseudo	R2	=	0.1123
process innovation	Coefficient	Std. Err.	Z-value	P-value		Marginal Effect
The period of operation (Logarithm)	-0.130	0.209	-0.62	0.53		-0.027
Capital (Logarithm)	-0.054	0.132	-0.40	0.69		-0.011
Number of mid-career hiring employees for recent three years	0.025	0.014	1.79	0.07	*	0.005
Manufacturing	1.268	0.971	1.31	0.19		0.266
Information	0.303	1.037	0.29	0.77		0.064
Service	1.260	1.064	1.18	0.24		0.265
Construction	1.112	0.985	1.13	0.26		0.234
ICT index	0.234	0.088	2.67	0.01	***	0.049
Increase or decrease of R&D expense for recent three years	0.622	0.195	3.19	0.00	***	0.131
The employees' concern	0.329	0.132	2.49	0.01	**	0.069
The top manager's participation	0.350	0.143	2.44	0.02	**	0.074
Constant	-1.822	1.667	-1.09	0.27		

Notes: * significant at 10%; ** significant at 5%; *** significant at 1%
Source: Authors

3.3.4. Relationship between effect of ICT use and innovation

Finally, "Sharing information by ICT use" and "Developing new product by ICT use" as the effect of ICT use were added to the explanatory variables in the models shown in the previous 3.3.3. Logit regression analysis was conducted.

As a results, however, ICT index was not significant, while "capital (logarithm)" ($p<0.00$), "Number of mid-career employees recruited in the recent three years" ($p<0.02$), "Increase or decrease in R&D expenditures in the recent three years" ($p<0.00$), and "Top

manager's participation" (p<0.00), were significant. "Developing new product by ICT use" (<0.04) became positively significant in case of product innovation (Table 19). On the other side, in addition to ICT index (p<0.06), "Number of mid-career employees recruited in the recent three years" (p<0.04) and "Increase or decrease in R&D expenditures in the recent three years" (p<0.00), both "Sharing information by ICT use" (p<0.00) and "Developing new product by ICT use" (p< 0.00) became positively significant in case of process innovation (Table 20).

From these results, Hypothesis 4 is verified in case of process innovation. On the other hand, "Developing new product by ICT use" is not verified in case of product innovation, "Sharing information by ICT use" was not verified in case of product innovation.

Table 19. Relationship between the effect of ICT use and product innovation

		Number	Of	Obs	=	335
			LR	chi2(12)	=	103.63
		Prob	>	chi2	=	0
			Log	likelihood	=	-135.74112
			Pseudo	R2	=	0.2763
product innovation	Coefficient	Std. Err.	Z- value	P-value		Marginal Effect
The period of operation (logarithm)	-0.014	0.279	-0.05	0.96		-0.002
Capital (Logarithm)	0.565	0.190	2.98	0.00	***	0.073
Number of mid-career hiring employees for recent three years	0.075	0.033	2.26	0.02	**	0.010
Manufacturing	-0.777	1.767	-0.44	0.66		-0.101
Information	0.074	1.941	0.04	0.97		0.010
Service	-0.595	1.778	-0.33	0.74		-0.077
Construction	-1.574	1.787	-0.88	0.38		-0.204
ICT index	0.166	0.121	1.38	0.17		0.021
Sharing information by ICT use	0.039	0.186	0.21	0.84		0.005
Developing new product by ICT use	0.413	0.197	2.10	0.04	**	0.054
Increase or decrease of R&D expense for recent three years	0.930	0.264	3.52	0.00	***	0.121
The employees' concern	0.086	0.171	0.50	0.62		0.011
The top manager's participation	0.884	0.193	4.58	0.00	***	0.115
Constant	-4.770	2.470	-1.93	0.05	*	

Notes: * significant at 10%; ** significant at 5%; *** significant at 1%
Source: Authors

Table 20. Relationship between the effect of ICT use and process innovation

		Number	Of	obs	=	334
			LR	chi2(12)	=	74.56
		Prob	>	chi2	=	0
			Log	likelihood	=	-191.32594
			Pseudo	R2	=	0.1631
process innovation	Coefficient	Std. Err.	Z-value	P-value		Marginal Effect
The period of operation (Logarithm)	-0.032	0.219	-0.15	0.88		-0.006
Capital (Logarithm)	-0.135	0.139	-0.97	0.33		-0.026
Number of mid-career hiring employees for recent three years	0.032	0.015	2.07	0.04	**	0.006
Manufacturing	0.962	1.091	0.88	0.38		0.188
Information	-0.198	1.213	-0.16	0.87		-0.039
Service	1.049	1.175	0.89	0.37		0.205
Construction	1.067	1.124	0.95	0.34		0.208
ICT index	0.180	0.095	1.89	0.06	*	0.035
Sharing information by ICT use	0.570	0.169	3.38	0.00	***	0.111
Developing new product by ICT use	0.517	0.169	3.07	0.00	***	0.101
Increase or decrease of R&D expense for recent three years	0.589	0.206	2.87	0.00	***	0.115
The employees' concern	0.209	0.143	1.46	0.14		0.041
The top manager's participation	0.246	0.154	1.60	0.11		0.048
Constant	-1.235	1.773	-0.70	0.49		

Notes: * significant at 10%; ** significant at 5%; *** significant at 1%
Source: Authors

In addition, “Effect of ICT use” which was the explanatory variable of the previous models was replaced with a new variable which is the cross term of “Effect of ICT use” times “ICT index," which indicates whether ICT index shows effect, namely whether SMEs with larger index actually show better performance of ICT. “Effect of ICT use” itself does not necessarily show that those SMEs have larger ICT index Again logit regression analysis was conducted. As shown in Table 19, the new cross term variable (Developing new product by ICT use * ICT index)" ($p<0.04$) became positively significant in case of product innovation (Table 21). Both the cross term (Sharing information by ICT use * ICT index)" ($p<0.01$) and the cross term (Developing new product by ICT use * ICT index) ($p<0.02$)" became positively significant in case of process innovation (Table22) as well as Table 20. Based on these results, it is confirmed that SMEs with the more developed level of ICT yielded the larger effect of ICT.

Table 21. Relationship between cross term interaction (effect of ICT use * ICT index) and product innovation

		Number	Of	Obs	=	335
			LR	chi2(12)	=	103.74
		Prob	>	chi2	=	0
			Log	likelihood	=	-135.68558
			Pseudo	R2	=	0.2766
product innovation	Coefficient	Std. Err.	Z-value	P-value		Marginal Effect
The period of operation (Logarithm)	-0.080	0.276	-0.29	0.77		-0.010
Capital (Logarithm)	0.571	0.189	3.02	0.00	***	0.074
Number of mid-career hiring employees for recent three years	0.074	0.033	2.21	0.03	**	0.010
Manufacturing	-0.893	1.816	-0.49	0.62		-0.116
Information	-0.094	1.997	-0.05	0.96		-0.012
Service	-0.768	1.824	-0.42	0.67		-0.100
Construction	-1.880	1.838	-1.02	0.31		-0.244
ICT index	0.166	0.135	1.23	0.22		0.022
Cross term (Sharing information by ICT use * ICT index)	0.026	0.122	0.21	0.83		0.003
Cross term (Developing new product by ICT use * ICT index)	0.312	0.153	2.04	0.04	**	0.041
Increase or decrease of R&D expense for recent three years	0.928	0.264	3.51	0.00	***	0.121
The employees' concern	0.100	0.168	0.59	0.55		0.013
The top manager's participation	0.881	0.194	4.54	0.00	***	0.115
Constant	-4.432	2.508	-1.77	0.08	*	

Notes: * significant at 10%; ** significant at 5%; *** significant at 1%
Source: Authors

4. Discussion and Conclusion

This paper constructed the ICT index according to the level of ICT use, and examined whether innovation is promoted by SMEs with the higher ICT index is. The results obtained revealed that SMEs that used ICT for new product development such as collecting customers' needs achieved more product as well as process innovation. In addition, it is confirmed that SMEs which positively shared information using ICT achieved more process innovation.

It was also verified that innovative SMEs positively used ICT, hired mid-career employees and raised R&D expenditures to promote product as well as process innovation. Moreover, top management's participation was indispensable for both product and process innovation, and employees' morale was important for process innovation.

As a result, the followings become clear: (i) Top management's participation in the project, and investment in R&D activity from the strategic standpoint; (ii) to employ mid-career persons from outside the firm, and to acquire new knowledge and (iii) to promote ICT use for the new product development to collect customers' needs are necessary for SMEs to achieve product innovation. In addition to the above-mentioned three points for product innovation, the followings are important for process innovation: (iv) to improve employee's morale toward innovation; and (v) to promote to share information by ICT. These imply that top management should demonstrate leadership, and manage the product innovation process through top-down including the promotion of ICT use. On the other hand, not only managers but also employees have to act flexibly and autonomously to share information by ICT are important in the process innovation that is required to restructure existing business processes.

It should be discussed on the direction of future research. The construction of the ICT index in this paper is rather primitive and it needs to be elaborated further. Another use of the index is to match it with business strategy, that is, how business strategy is different according to the different level of the ICT use. Furthermore, by making use of the index, the suitable strategic policy can be proposed according to the maturity level of ICT so that SMEs can engage in innovation properly.

Table 22. Relationship between cross term (effect of ICT use * ICT index) and process innovation

		Number	Of	obs	=	334
			LR	chi2(12)	=	64.3
		Prob	>	chi2	=	0
			Log	likelihood	=	-196.45514
			Pseudo	R2	=	0.1406
process innovation	Coefficient	Std. Err.	Z-value	P-value		Marginal Effect
The period of operation (Logarithm)	-0.112	0.217	-0.51	0.61		-0.023
Capital (Logarithm)	-0.095	0.137	-0.69	0.49		-0.019
Number of mid-career hiring employees for recent three years	0.031	0.015	2.09	0.04	**	0.006
Manufacturing	0.904	1.048	0.86	0.39		0.183
Information	-0.319	1.190	-0.27	0.79		-0.065
Service	0.896	1.134	0.79	0.43		0.182
Construction	0.773	1.077	0.72	0.47		0.157
ICT index	0.141	0.103	1.37	0.17		0.029
Cross term (Sharing information by ICT use * ICT index)	0.277	0.108	2.58	0.01	**	0.056
I Cross term (Developing new product by ICT use * ICT index)	0.213	0.108	1.98	0.05	**	0.043
Increase or decrease of R&D expense for recent three years	0.604	0.202	2.99	0.00	***	0.123
The employees' concern	0.274	0.138	1.99	0.05	**	0.056
The top manager's participation	0.273	0.150	1.81	0.07	*	0.055
Constant	-1.178	1.747	-0.67	0.50		

Notes: * significant at 10%; ** significant at 5%; *** significant at 1%
Source: Authors

Note

[1)] 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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