INTERNATIONAL JOURNAL OF INTEGRATED ENGINEERING
ISSN: 2229-838X e-ISSN: 2600-7916

IJIE

Vol. 16 No. 2 (2024) 132-143
https://publisher.uthm.edu.my/ojs/index.php/ijie

A Study on Prerequisite Steps and Decision Making to Increase a Provability of Innovation in Mechanical Engineering SMEs

Shigeyuki Haruyama[1], Kojiro Fujiyama[2]*, Koji Masuda[2]

[1] *Graduate School of Innovation and Technology Management, Yamaguchi University 2-16-1 Tokiwadai, Ube-shi, Yamaguchi, 755-8611, JAPAN*
[2] *Graduate School of Science and Technology for Innovation, Yamaguchi University 2-16-1 Tokiwadai, Ube-shi, Yamaguchi, 755-8611, JAPAN*

*Corresponding Author: haruyama@yamaguchi-u.ac.jp
DOI: https://doi.org/10.30880/ijie.2024.16.02.014

Article Info

Received: 14 December 2023
Accepted: 25 April 2024
Available online: 17 May 2024

Keywords

Mechanical engineering, SMEs, innovation, niche top, prerequisite

Abstract

This study is a case study of two Japanese SMEs, Y and O, that have created core technologies through mechanical engineering, achieved sustainable growth through technological innovation, and achieved niche top company status. Companies need to generate innovation to achieve sustainable growth, and various studies have been conducted on innovation models. It has also been shown that innovation is not a one-off event but a process and that it is important to manage the process appropriately. In this context, we propose a four-stage process, beginning with the "generating value" step as a framework for the innovation process of a company aiming for sustainable growth. To increase the certainty of innovation, management needs to understand the readiness of the innovation process to determine the decision to execute the process. Accordingly, this study proposed a method to check the readiness of the innovation process by creating a "state diagram of sub-elements for the prospect of generating innovations" to help management determine the decision to execute the process before the "generating value" step of the innovation process. In order to confirm the validity of the state diagram, we examined how the management of company Y's refrigerated vehicle business and company O's mower business have judged their decision-making to implement the innovation process, based on a review of company documents and interviews with the management. The results of the comparative verification between the state diagrams and actual results are reported.

1. Introduction

While various studies have been conducted on the management of small and medium-sized enterprises (SMEs) [1] [2] [3]. This study discusses the following "what processes are necessary for SMEs that create core technologies through mechanical engineering and achieve sustained growth through technological innovation to manage the process of product development in a way that positions the company's core technologies at the center and considers market developments?". Companies need to generate innovation to grow sustainably [4] [5], and various studies have been conducted on models of innovation [5] [6] [7] [8]. It has also been shown that innovation is not a one-off event, but a process, and that it is important to manage the process appropriately [9] [10] [11]. We believe that before managing the process, a growth strategy concept should take into account the company's technological strengths, the market it aims to serve, and its performance, for the following reasons.

Many companies in the world use mechanical engineering to conduct their business [12]. While some of them, such as Toyota [13] and GE [14], are large companies that have successfully innovated and grown their businesses, for many companies it is still not easy to generate innovation and much research is being conducted to solve this issue [5] [16] [17]. The importance of envisioning growth through innovation early in the innovation process has been discussed by many researchers [9] [16] [18] [19]. In addition, several researchers have proposed frameworks to be used for this purpose [17] [20] [21]. However, it is not easy not to get the innovation process off to a false start, as shown by the statement that most innovations are messy, with false starts, dead ends, and out-of-sequence jumps [22]. In order to prevent false starts by management and to increase the certainty of innovation emergence, it is necessary to ascertain the readiness of the innovation process to determine the decision to execute the process or not.

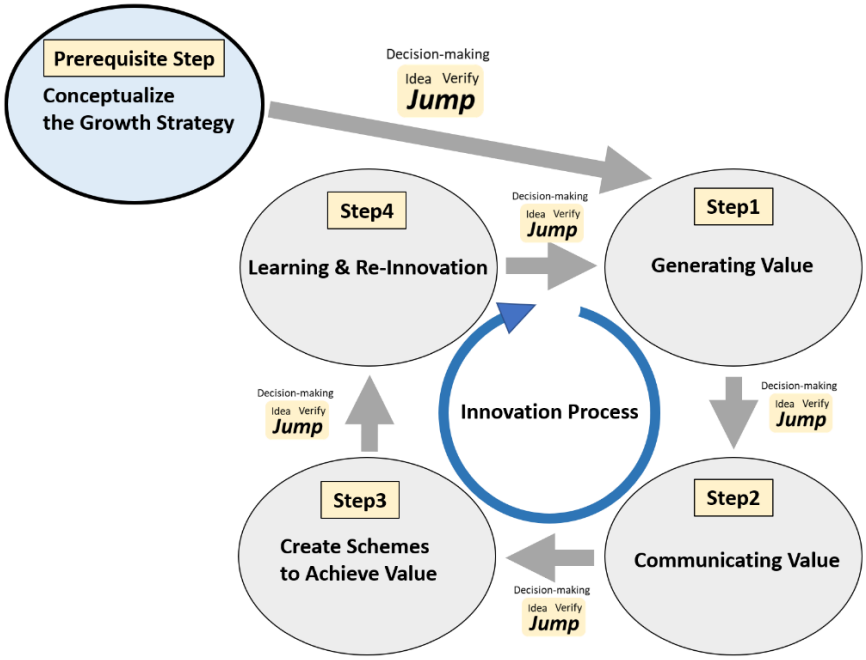

Fig. 1 *Conceptual diagram showing the basic structure of the innovation process and prerequisite step*

Accordingly, this study proposes a method to check the readiness of the innovation process before the "generating value" step of the innovation process for management to determine the decision to execute the process. Decision-making is said to be the most important act in business [23] [24]. Its basic structure has been shown by previous studies, and according to Itami,2022 [25] it consists of three steps: idea, verify, and jump. By setting the "prerequisite step" before the "generating value" step of the innovation process, we suggest that management should conceive a growth strategy that takes into account the company's technological strengths, target market, and performance, and jump to the "generating value" step of the innovation process before the "jump" step. By confirming the readiness of the innovation process before making the jump to the "generating value" step of the innovation process, we believe that it will be possible to make a decision on the execution of the process by enabling idea and verify for decision-making.

Int. Journal of Integrated Engineering Vol. 16 No. 2 (2024) p. 132-143

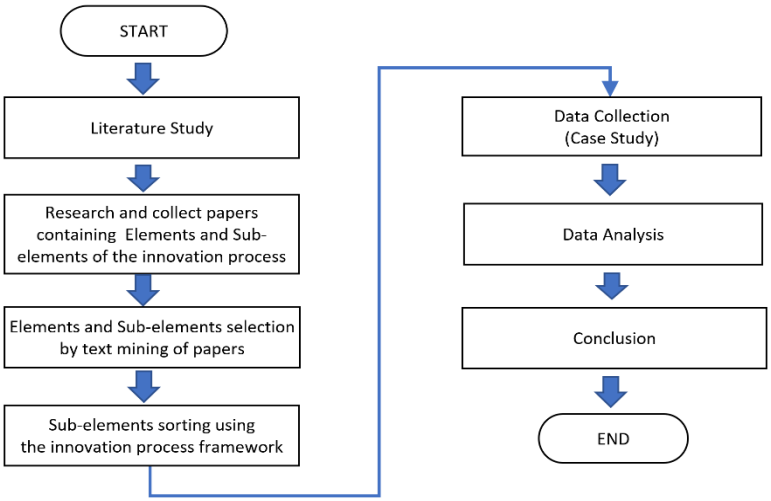

Fig. 2 *Research flowchart*

Table 1 *List of papers that were text-mined (Innovation process step 1)*

	Search word	Paper title	Authors	Number of citations on Google Scholar in Sep 2023	Publication year
1	Management, Innovation, Foresight	Corporate foresight: Its three roles in enhancing the innovation capacity of a firm	Rohrbeck, R H. G. Gemünden,	481	2010
2	Management, Innovation, Foresight	Corporate Foresight: An Emerging Field with a Rich Tradition	Rohrbeck, R, Battistella, C E. Huizingh	385	2015
3	Management, Innovation, Foresight	Strategic foresight for collaborative exploration of new business fields	Tobias Heger René Rohrbeck	252	2012
4	Management, Innovation, Foresight	Corporate foresight and innovation management: A portfolio-approach in evaluating organizational development	HA Von Der Gracht CR Vennemann IL Darkow	220	2010
5	Management, Innovation, Foresight	The impact of foresight on innovation policy-making: recent experiences and future perspectives	A Havas, D Scharrtinger M Weber	207	2010
6	Management, Innovation, Customer Value	Customer Value: The Next Source for Competitive Advantage	RB Woodruff	9398	1997
7	Management, Innovation, Customer Value	Market orientation, customer value, and superior performance	SF Slater, JC Narver	1561	1994
8	Management, Innovation, Customer Value	Intelligence generation and superior customer value	SF Slater, JC Narver	1090	2000
9	Management, Innovation, Customer Value	Interactions in virtual customer environments: Implications for product support and customer relationship management	S Nambisan, RA Baron	998	2007
10	Management, Innovation, Customer Value	Customer value change in industrial marketing relationships: a call for new strategies and research	DJ Flint, RB Woodruff SF Gardial	799	1997
11	Management, Innovation, Market Value	Corporate social responsibility, customer satisfaction, and market value	R BLUNDELL R GRIFFITH J VAN REENEN	4780	2006
12	Management, Innovation, Market Value	Innovation management measurement: A review	Richard Adams John Bessant Robert Phelps	2438	2006
13	Management, Innovation, Market Value	Relationship between Innovativeness, Quality, Growth, Profitability, and Market Value	HJ Cho, V Pucik	1668	2005
14	Management, Innovation,	Strategic innovation at the base of the pyramid	J Anderson, C Markides	664	2007

15	Market Value Management, Innovation, Market Value	Innovation with Limited Resources: Management Lessons from the German Mittelstand	A De Massis, D Audretsch L Uhlaner N Kammerlander	404	2018
16	Management, Innovation, Social Value	The private and social value of information and the reward to inventive activity	J Hirshleifer	2791	1978
17	Management, Innovation, Social Value	Social entrepreneurship: Towards conceptualisation	GS Mort, J Weerawardena K Carnegie	1578	2003
18	Management, Innovation, Social Value	The blended value proposition: Integrating social and financial returns	J Emerson	1234	2003
19	Management, Innovation, Social Value	Social entrepreneurship: Key issues and concepts	ST Certo, T Miller	1023	2008
20	Management, Innovation, Social Value	Measuring social value	G Mulgan	458	2010
21	Management, Innovation, Core Technology	YOU NEED AN INNOVATION STRATEGY	GARY P. PISANO	864	2015
22	Management, Innovation, Core Technology	Organizational Linkages for Surviving Technological Change: Complementary Assets, Middle Management, and Ambidexterity	A Taylor, CE Helfat	612	2009
23	Management, Innovation, Core Technology	High-Technology spinoffs from government R&D laboratories and research universities	EG Carayannis EM Rogers K Kurihara, MM Allbritton	548	1998
24	Management, Innovation, Core Technology	Holistic Innovation: An Emerging Innovation Paradigm	Jin Chen, Ximing Yin Liang Mei	262	2018
25	Management, Innovation, Core Technology	Complexity and learning behaviors in product innovation	R Chapman, P Hyland	235	2004

We also thought that if managers could make decisions based on idea and verify based on the "state diagram of sub-elements for the prospect of generating innovations," it would help them "establish a prospect" to increase the probability of innovation and prevent false starts of innovation. This would help to prevent false starts. Fig. 1 shows a conceptual diagram of the innovation process and the basic structure of the prerequisite steps. We focus on the innovation process as presented in Haruyama, 2022 [11] and consider the innovation process to consist of four steps and 12 elements: generating value, communicating value, creating schemes to achieve value, and learning & re-innovation.

In addition, "planning the prospects" for success to increase the probability of innovation is defined as the conception in advance of whether or not the innovation process (generating value, communicating value, creating schemes to achieve value, and learning & re-innovation) can be implemented and the state of readiness for it. The 12 elements of the innovation process may be used by managers to develop innovation prospects, but the 12 elements are abstract and difficult to use in preparing for innovation. The elements to be used for forecasting need to be more concrete. Therefore, in this study, we attempted to extract several sub-elements belonging to the 12 elements of the innovation process so that establish innovation prospects and to make the meaning of the elements more concrete.

Furthermore, a "state diagram of sub-elements for the prospect of generating innovations" was created to help managers make decisions on process execution before the "generating value" step of the innovation process, and was proposed as a method for confirming the readiness of the innovation process. In order to verify the comparison between this state diagram and actual results, we examined how the management of company Y's refrigerated vehicle business and company O's mower business, which have achieved sustainable growth through technological innovation, have judged the decision to implement the innovation process, based on a review of company documents and interviews with the management team of each company. The study was based on a review of company documents and interviews with management.

2. Methods and Results

In order to create a "state diagram of sub-elements for the prospect of generating innovations" to be used as a method to check the readiness of the innovation process, it is necessary to use more specific sub-elements than the 12 elements of the innovation process. Therefore, in this study, we surveyed papers that are related to the

Int. Journal of Integrated Engineering Vol. 16 No. 2 (2024) p. 132-143

innovation process elements we proposed in our previous study [26] and attempted to identify sub-elements using text mining. Products have a product life cycle, and prior research [11] [26] has shown that it is important to manage the elements in the "generating value" step during the creation phase. Therefore, we focused on the "generating value" step of the innovation process and surveyed relevant papers on five elements (foresight and discoverability, customer value, market value, social value, and core technology). The research flowchart is shown in Fig. 2.

2.1 Extraction of Candidate Sub-elements (Selection of Papers)

Google Scholar was selected and used to research papers because of its wide range of data sources. For each of the five elements in step 1 “generating value” of the innovation process, and search was conducted, adding innovation and management for each term. The five papers with the highest number of citations were selected from the 10 pages of search results. The results are shown in table 1 List of papers that were text-minded (Innovation process Step 1).

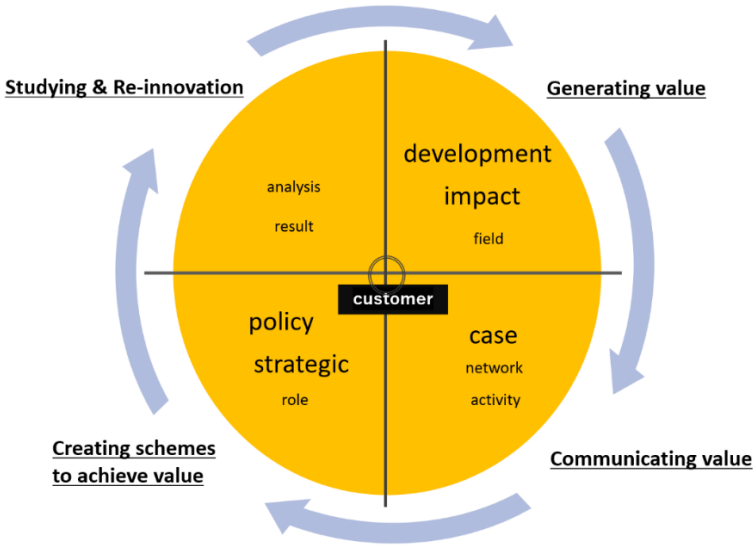

Fig. 3 *State diagram of sub-elements for the prospect of generating innovations (foresight, discoverability)*

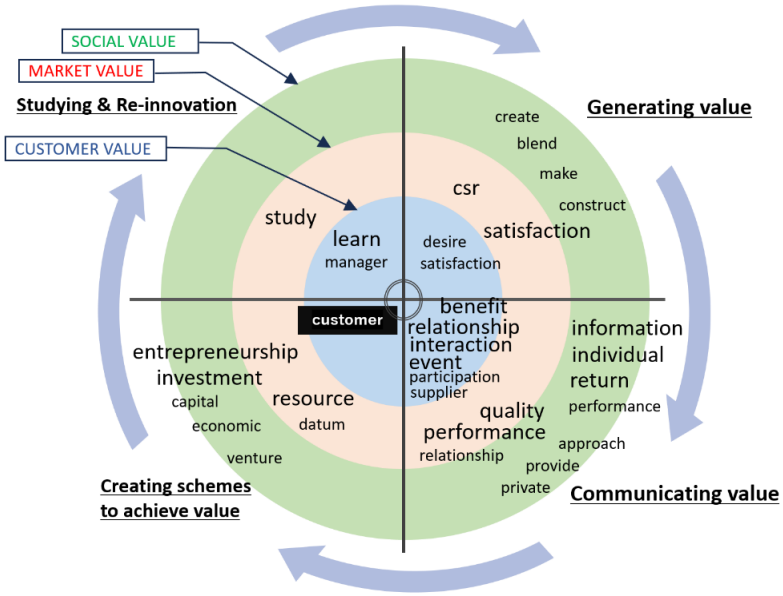

Fig. 4 *State diagram of sub-elements for the prospect of generating innovations (Customer value, market value, social value)*

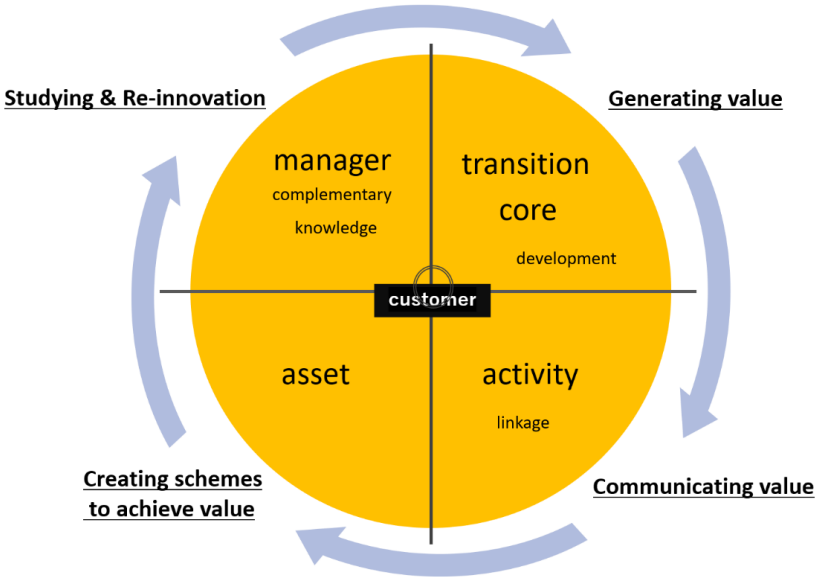

Fig. 5 *State diagram of sub-elements for the prospect of generating innovations (Core technology)*

2.2 Extraction of Candidate Sub-elements (Noise Removal of Papers)

In this study, for the purpose of improving the accuracy of text mining, the figures, tables, headers, and footers included in the papers were removed after the papers were converted to text.

2.3 Extraction of Candidate Sub-elements (Population Formation of Elements and Sub-elements Candidates by Text Mining)

In this study, MATLAB by MathWorks was used for text mining, and the top words of the results shown in bag-of-words were employed as candidate elements and sub-elements of the innovation process, and a population of candidate sub-elements was formed for five elements (foresight and population formation of sub-element candidates was conducted for five elements (foresight and discoverability, customer value, market value, social value, and core technology).

Table 2 *Results of sub-elements selection using the innovation process framework*

	Steps of Innovation Process		Elements of Innovation Process	Foresight, Discoverability	Customer Value	Market Value	Social Value	Core Technology	1st Step
1	Generating Value (1st step)	(1)	Foresight, Discoverability	foresight future new **development** **impact** **field** technology	value new market **desire** **satisfaction**	market **csr** value **satisfaction**	social value market new **create** **blend** **make** **construct**	technology new **transition** **core** **development**	new social foresight market future technology value
		(2)	Customer Value						
		(3)	Market Value						
		(4)	Social Value						
		(5)	Core Technology						
2	Communicating Value (2nd step)	(6)	Product	innovation research need **case** **network** **activity**	customer product **benefit** **interaction** **relationship** example **event** **participation** research **supplier** need	innovation customer **quality** product innovativenes s **performance** research **relationship**	**information** **individual** **return** **performance** **approach** **provide** example **private**	innovation product **activity** **linkage** research customer	customer innovation product research need example
		(7)	Architecture, Development Capability						
		(8)	Process Development, Customer Relations						
3	Create Schemes to Achieve Value (3rd step)	(9)	Ability to Develop and Plan Business Models	corporate process management company **policy** **strategic** **role** organizational	organization firm process	firm model **resource** management company process **datum**	**entrepreneurshi** **p** **investment** organization **capital** **economic** **venture**	company organizational management organization **asset** process	management company process organization firm corporate model organizational
		(10)	Strategy Planning						
		(11)	Market Creation						
4	Learning & Re-Innovation (4th step)	(12)	Study, Re-Innovation	business change **analysis** **result**	change **learn** **manager** business	measure **study**	measure business	**manager** business **complementar** **y** **knowledge**	business measure change

2.4 Extraction of Candidate Sub-elements (Text Mining of Value-creating Steps for Use in Sorting Elements and Sub-elements)

As a method for sorting elements and sub-elements, text mining of the generating value step (1st step) (5 papers x 5 elements = text mining results of 25 papers) was conducted and used to sort elements and sub-elements.

Table 3 *Readiness checklist for the innovation process (Foresight/discoverability, customer value, market value)*

Elements of Innovation Process	Steps of Innovation Process	Sub-elements of Innovation Process	Before making the decision to move to the innovation process, have you prepared for the following Sub-elements?	Sentences for questions
Foresight, Discoverability	1st Step	development	Yes / No	Find a **field** that has an **impact** on business growth and conduct **development** in that field.
		impact	Yes / No	
		field	Yes / No	
	2nd Step	case	Yes / No	Find **cases** of specific customer problems and use the **network** to execute value-creating **activities**.
		network	Yes / No	
		activity	Yes / No	
	3rd Step	policy	Yes / No	Clarify management's **policy** and the company's **role** and have a **strategic** value generation concept.
		strategic	Yes / No	
		role	Yes / No	
	4th Step	analysis	Yes / No	Conduct a dispassionate **analysis** of the **results** of the project, leading to the next level of foresight and discoverability.
		result	Yes / No	
Customer Value	1st Step	desire	Yes / No	To accurately understand customers' **desires** and identify fields of business that provide **satisfaction** to customers.
		satisfaction	Yes / No	
	2nd Step	benefit	Yes / No	The **relationship** not only with customers but also with **suppliers** creates **interactions** and **benefits**. **Participation** in **events** of customers and suppliers is also important to gain benefits.
		interaction	Yes / No	
		relationship	Yes / No	
		event	Yes / No	
		participation	Yes / No	
		supplier	Yes / No	
	3rd Step	Text mining of the "Generating Value" paper was unable to identify Sub-elements.		
	4th Step	learn	Yes / No	In the learning and re-innovation step, it is important for the **managers** themselves to **learn**.
		manager	Yes / No	
Market Value	1st Step	csr	Yes / No	We envision value creation that fulfills corporate social responsibility (**csr**) and achieves market **satisfaction**.
		satisfaction	Yes / No	
	2nd Step	quality	Yes / No	We are concerned about **quality** and **performance**, conduct research to improve them, and create good **relationships** with customers and suppliers.
		performance	Yes / No	
		relationship	Yes / No	
	3rd Step	resource	Yes / No	To communicate value to the market, the company evaluates the input of management **resources** based on **datum**.
		datum	Yes / No	
	4th Step	study	Yes / No	It is important for managers to **study**.
	4th Step	manager	Yes / No	It is important for **managers** to act to acquire **complementary** skills and **knowledge** for their companies.
		complementary	Yes / No	
		knowledge	Yes / No	

Int. Journal of Integrated Engineering Vol. 16 No. 2 (2024) p. 132-143

2.5 Selection of Sub-elements

We propose a framework for the innovation process of firms seeking sustainable growth, consisting of a four-step process and 12 elements, starting with "generating value." We used this framework to select sub-elements and sorted the text mining results into 4 steps. For each of the four steps, the difference between the candidate sub-elements of the element and the candidate sub-elements of the 1st step was taken and used as sub-elements. The results are noted in Table 2: Results of sub-element sorting using the innovation process framework. In the table, the words marked in bold letters in the foresight and discoverability, customer value, market value, social value, and core technology columns indicate sub-elements.

Table 4 *Readiness checklist for the innovation process (Social value, core technology)*

Elements of Innovation Process	Steps of Innovation Process	Sub-elements of Innovation Process	Before making the decision to move to the innovation process, have you prepared for the following Sub-elements?	Sentences for questions
Social Value	1st Step	create	Yes / No	To **make** new products that **create** new value, we construct new relationships not only with companies, but also with individuals, ventures, or partners with whom they are **blended**.
		blend	Yes / No	
		make	Yes / No	
		construct	Yes / No	
	2nd Step	information	Yes / No	Providing **information** to **individual** stakeholders is important. If the **performance** of **return** is good, it is possible to **provide** value to a large number of individuals, and at the same time, it is easy to take a PR **approach**. In order to increase social value, it is important to respond to **private** parties.
		individual	Yes / No	
		return	Yes / No	
		performance	Yes / No	
		approach	Yes / No	
		provide	Yes / No	
		private	Yes / No	
	3rd Step	entrepreneurship	Yes / No	Execute **investment** with **entrepreneurship**. In order to grow an **organization**, it is necessary to have sufficient **capital** and to be **economically** independent, but it is also important to always maintain the feeling as if you are the manager of a **venture** company, even if the company grows large.
		investment	Yes / No	
		capital	Yes / No	
		economic	Yes / No	
		venture	Yes / No	
	4th Step	Text mining of the "Generating Value" paper was unable to identify Sub-elements.		
Core Technology	1st Step	transition	Yes / No	Technology is not constant, but **transitions** to new things. In order to cope with this transition, **development** of **core** technologies should be carried out without fail.
		core	Yes / No	
		development	Yes / No	
	2nd Stage	activity	Yes / No	**Activity** to accelerate **linkage** is useful for growth strategy conceptualization.
		linkage	Yes / No	
	3rd Step	asset	Yes / No	The investment required to generate social value is significant. Always be aware of the effective use of company **assets** to acquire core technologies.
	4th Step	manager	Yes / No	It is important for **managers** to act to acquire **complementary** skills and **knowledge** for their companies.
		complementary	Yes / No	
		knowledge	Yes / No	

2.6 Creating a "Sub-element State Diagram for the Prospect of Generating Innovations"

From the results of sub-element selection using the innovation process framework, we developed the three state diagrams described below.

- State diagram of sub-elements for the prospect of generating innovations (foresight, discoverability)

As shown in Fig. 3, the four steps of the innovation process were arranged in a circle as a rotating cycle, and the sub-elements of foresight and discoverability were created by placing them in the relevant steps. The large sub-elements in the font have higher text mining results, indicating that they are highly important in preparing for the innovation process.

- State diagram of sub-elements for the prospect of generating innovations (customer value, market value, social value)

The customer value sub-element was placed in the central area, as shown in Fig. 4. The market value sub-element was placed in its outer area. The social value sub-element was placed in the outermost area. This provided a conceptual representation of the market spread in the innovation process. The rest of the procedure was the same as in Fig. 3.

- State diagram of sub-elements for the prospect of generating innovations (Core technology)

The sub-elements of the core technology were created by placing them in the relevant steps, as shown in Fig. 5.
Other steps were created in the same manner as in Fig. 3.

2.7 Element Embodiment by Sub-Elements

Using the sub-elements related to the five elements of the value-creation step "foresight and discoverability," "customer value," "market value," "social value," and "core technology," as expressed in "results of sub-elements selection using the innovation process framework" (2-5), the 12 elements of the innovation process were embodied in the document. The 12 elements of the innovation process were embodied by the document using the sub-elements related to the five elements of the value creation step: "foresight and discoverability," "customer value," "market value," "social value," and "core technology". The results were compiled as a sheet to be used in interviews with managers to determine the readiness of the innovation process. Table 3 shows the Readiness checklist for the innovation process （foresight / discoverability, customer value, market value）. Table 4 shows the readiness checklist for the innovation process （social value, core technology）.

3. Discussion

3.1 Case Study on Company Y's Refrigerated Vehicle Business

The "sub-elements state diagram for the prospect of generating innovations." created in 2-6 and the "readiness checklist for innovation process" created in 2-7 were used to compare and verify the performance of company Y's refrigerated vehicle business with that of company Y. The results were compared and verified with those of company Y's refrigerated truck business using the "sub-elements state diagram for the prospect of generating innovations. The results are summarized in Table 5 "case study results for company Y". Since this study focused on the "generating value" step of the innovation process, the case study was also conducted on the "generating value" step. Table 5 shows that company Y had implemented a state of readiness for the prospect of generating innovations for many of the sub-elements shown in the state diagram of sub-elements for the prospect of generating innovations, with more than 70% of the sub-elements being implemented.

Table 5 *Case study results for company Y*

Elements of Innovation Process	Sub-elements of Innovation Process	Did you conceptualize this Sub-elements before making the decision to start the innovation process?	Review of corporate documents and content of interviews with management (Company Y)
Foresight, Discoverability	development	Yes	Company Y found a **field** of business growth with **impact**, the refrigerated truck business, which no one else in Japan was involved in, and **developed** it for Company F, which was requested by the U.S. military.
	impact	Yes	
	field	Yes	
Customer Value	desire	Yes	Company Y, in cooperation with Company F, has found a business field that provides **satisfaction** to customers by accurately understanding the **desire** of farmers in Kyushu to send fresh beans to distant customers and fishermen to deliver fresh fish to distant customers, starting with the **desire** to eat US military ice cream in Kyushu.
	satisfaction	Yes	
Market Value	csr	Yes	Company Y has adopted a policy of "Y Spirit," which is to take on challenges by focusing on the needs of each customer, one unit at a time, for 100 different companies. By practicing this policy, the company pursues market **satisfaction** while fulfilling its corporate social responsibility (**csr**).
	satisfaction	Yes	
Social Value	create	No	The survey found no applicable cases.
	blend	No	
	make	No	
	construct	No	

Int. Journal of Integrated Engineering Vol. 16 No. 2 (2024) p. 132-143

Core Technology	transition	Yes	Company Y is constantly **developing** new products to solve its customers' problems, and is continuously **transitioning** to new products without stopping at a single product, striving to acquire **core** technologies, such as Japan's first technology for manufacturing refrigerated vehicles.
	core	Yes	
	development	Yes	

3.2 Case Study on Company O's Slope Mower Business

The "sub-elements state diagram for the prospect of generating innovations." created in 2-6 and the "readiness checklist for innovation process" created in 2-7 were used to compare and verify the performance of company O's slope mower business with that of company O. The results were compared and verified with those of company O's slope mower business using the "sub-elements state diagram for the prospect of generating innovations. The results are summarized in table 6 "case study results for company O". Since this study focused on the "generating value" step of the innovation process, the case study was also conducted on the "generating Value" step. Table 6 shows that company O had implemented the preparation of the innovation process for all the sub-elements indicated in the sub-elements state diagram for the prospect of generating innovations.

Table 6 *Case study results for company O*

Elements of Innovation Process	Sub-elements of Innovation Process	Did you conceptualize this Sub-elements before making the decision to start the innovation process?	Review of corporate documents and content of interviews with management (Company O)
Foresight, Discoverability	development	Yes	Company O found a **field** of slope mowers, which no one else in Japan was working on, as a field that would have an **impact** on business growth, and carried out **development**.
	impact	Yes	
	field	Yes	
Customer Value	desire	Yes	Company O's management accurately understood the farmers' **desire** for mobile mowing machines because mowing slopes is manual and hard work, and found a business field for slope mowers that would bring **satisfaction** to the farmers.
	satisfaction	Yes	
Market Value	csr	Yes	In order to fulfill its corporate social responsibility (**csr**), Company O added various derivative models to its slope mower models to **satisfy** the various needs of the market.
	satisfaction	Yes	
Social Value	create	Yes	Company O is **creating** new value by **making** new products and **constructing** relationships with customers in the agricultural sector, where there are many individuals, to meet a variety of **blend** customer needs.
	blend	Yes	
	make	Yes	
	construct	Yes	
Core Technology	transition	Yes	Company O's policy is to be "ultra-customer-oriented," creating industry firsts one after another, and it is continuously working on the **development** of **core** technologies, **transitioning** to new products without staying with a single product.
	core	Yes	
	development	Yes	

4. Conclusion

In this study, we discussed what processes are necessary for companies that create core technologies through mechanical engineering and achieve sustainable growth through technological innovation to position their core technologies at the center of the company, consider market developments, and execute product development. The following conclusions were reached because of the discussion. To increase the certainty of innovation, management needs to understand the readiness of the innovation process and determine the decision to execute the process. For management to determine the decision to execute the process, we proposed a method to check the readiness of the innovation process by creating a "state diagram of sub-elements for the prospect of generating innovations".

Through the case studies of the two companies, we confirmed that the proposed research was effective in the case of the two SMEs that successfully innovated, as a method to develop innovation prospects. In text mining, "weighted" analysis by the number of words in the papers was not conducted in this study. If the number of papers surveyed increases in the future, weighing the number of characters in text mining might be considered for improving the accuracy of text mining. This study focused on Step 1 (Generating Value) of the innovation process. In future studies, we would like to select sub-elements for Step 2, Step 3, and Step 4 as well.

References

[1] Marisa, F., Ahmad, S. S. S., Yusof, Z. I. M., Fachrudin, Aziz, T. M. A. (2019). Segmentation Model of Customer Lifetime Value in Small and Medium Enterprise (SMEs) using K-Means Clustering and LRFM Model, International Journal of Integrated Engineering, Vol. 11, No.3, 169-180. https://doi.org/10.30880/ijie.2019.11.03.018.

[2] Salim, S. A., Jaffar, S. (2020). A Review of Cloud-Based ERP Systems in SMEs, International Journal of Integrated Engineering, Vol. 12, No. 7, 113-120. https://doi.org/10.30880/ijie.2020.12.07.013.

[3] Harsoyo, Y. A., Wibowo, M. A., Hatmoko, J. U. D, Fitria, H. (2023). Combination of SCOR-BSC and Regression Linear Programming to Assess the Performance of Construction SMEs in DIY and Central Java, International Journal of Integrated Engineering Vol. 15, No. 1, p. 201-218. https://doi.org/10.30880/ijie.2023.15.02.020.

[4] Utterback, J. M. (1994). Mastering the Dynamics of Innovation, Harvard Business School Press

[5] Chesbrough, H. W. (2003). Open Innovation: The New Imperative for Creating and Profiting from Technology, Harvard Business School Press

[6] Rosenberg, N. (2009). Studies on Science and the Innovation Process: Selected Works of Nathan Rosenberg, World Scientific Pub Co Inc

[7] Rothwell, R. (1992). Towards the Fifth-generation Innovation Process, International Marketing Review

[8] Dodgson, M., Gann, D., Salter, A. (2005). Think, Play, Do: Innovation, Technology, and Organization: Technology, Innovation, and Organization 1st Edition, Kindle Edition, Oxford University Press

[9] Tidd, J., Bessant, J., Pavitt, K. (2001). Managing Innovation: 2nd edition

[10] Itami, H. (2009). Innovation Wo Okosu, Nikkei Publishing Inc.

[11] Haruyama, S., Fujiyama, K. (2022). A Study on the Relationship between "Managerial Decision Making" and "Factors Influencing Innovation Success" in Japanese Niche Top Firms, Salud, Ciencia y Tecnología. https://doi.org/10.56294/saludcyt2022193.

[12] Forbes Global 2000 (2023). on https://www.forbes.com/lists/global2000/?sh=158036a25ac0.

[13] Liker, J. (2004). The Toyota Way: 14 Management Principles from the World's Greatest Manufacturer 1st Edition, McGraw Hill

[14] Welch, J., Byrne, J. A. (2001). Jack: Straight from the Gut, Warner Books Inc.

[15] Christensen, C. M. (1997). The Innovator's Dilemma 1st (first) edition, Harvard Business School Press

[16] Ries, E. (2011). The Lean Startup: How Today's Entrepreneurs Use Continuous Innovation to Create Radically Successful Businesses, Currency

[17] Kim, W. C., Mauborgne, R. (2015). Blue Ocean Strategy, Expanded Edition: How to Create Uncontested Market Space and Make the Competition Irrelevant, Harvard Business Review Press

[18] Christensen, C. M., Raynor, M. E., & McDonald, R. (2015). "What is disruptive innovation?" Harvard Business Review, 93(12), 44-53

[19] Drucker, P. F., Maciariello, J. (1993). Innovation and Entrepreneurship, Harper Business

[20] Brown, T. (2019). Change by Design, Revised and Updated: How Design Thinking Transforms Organizations and Inspires Innovation, Harper Business

[21] Teece, D. J. (2010). Business Models, Business Strategy and Innovation, Long Range Planning 43, 172-194

[22] Tidd, J. (2006). A Review of Innovation Models, Imperial College London, 16, 0-17

[23] HBR's 10 Must Reads on Making Smart Decisions, (2013). Harvard Business Revies

[24] Riduan Yunus (2012). Decision Making Guidelines for Sustainable Construction of Industrialised Building Systems, Queensland University of Technology School of Urban Development Faculty of Built Environment and Engineering

[25] Itami, H. (2020). Keiei No Chiteki Shiko, Cyokkan De Hasso, Ronri De Kensho, Tetsugaku De Cyouyaku, TOYO KEIZAI INC., Tokyo

[26] Fujiyama, K., Oktavianty, O., Yano, S., Haruyama, S. (2022). A Study on Business Growth Factor to Create Innovation Process of Companies (Case Study in Refrigerated Truck Company), Journal of Engineering and Management in Industrial System Vol. 10, No. 1. https://doi.org/10.21776/ub.jemis.2022.010.01.