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Proposal for Management Method for Industry–Academia Collaborative Research using PoC Framework

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Abstract

To generate innovation from research results generated by universities and public research institutions, the research results should be transferred to companies. However, given that research results from universities and public research institutions are not initially intended for commercialization, additional research, and development are required to commercialize them. In addition, every organization has different objectives and characteristics, and research results are highly sticky information, making technology transfer difficult. Therefore, rather than simply providing information, technology transfer may be conducted through collaboration, such as collaborative research. Existing studies have proposed a framework for analyzing collaborative research between industry and academia from a proof-of-concept perspective and have analyzed the success factors. This present study proposes a method of using this framework (PoC framework) for the management of collaborative research between industry and academia for the purpose of commercialization. The proposed method can fill the knowledge gaps between industry and academia. The study found that a combination of the PoC framework and other frameworks (i.e. Value Proposition Canvas) is effective in the management method.

Keywords: collaborative research, commercialization, proof-of-concept, technology transfer

1 Introduction

Schumpeter [1] defined five types of innovations, which he said would bring about significant changes in social and economic activities. Drucker [2] defined innovation as the creation of better and more economic goods and services. Thus, innovation must refer not only to technological inventions or model proposals but also to the creation of new goods and services and their impact on social and economic activities. From another aspect, universities and public research institutions (hereafter referred to as “academia”) can create research results but not goods and services for society. Therefore, to create innovation based on research results, it is necessary to conduct business based on research results and to share and transfer knowledge in the form of research results with organizations that create goods and services.

The following two approaches are representative of the creation of goods and services by utilizing research results.

(1) Research results should be transferred to existing companies through collaborative research and others so that existing companies can create goods and services.

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(2) Startups are created by researchers who have created research results, and the startups are then involved in the creation of goods and services.

Each approach has its merits and demerits. The first approach has the advantage of utilizing the resources (human resources, production facilities, sales channels, funds, etc.) of existing companies. To commercialize research results, the value chain described by Porter should be established [3]. In the case of existing companies, businesses may be developed smoothly by utilizing the resources they already have. From another aspect, as a disadvantage, the results of research in academia, which are extremely close to basic research, need to be passed on to companies for business activities to promote additional research and development (R&D). In addition, technology is highly sticky knowledge, and transferring it accurately is very costly.

The advantage of the second approach is that the researcher who created the technology is involved in the commercialization of the technology himself. Therefore, there is no need to transfer the sticky knowledge of the technology between organizations. From another aspect, the disadvantage is that a new organization must be established, and resources, such as management, production technology, sales organization, and funds, must be acquired. Moreover, establishing a business environment is necessary, such as procurement channels and sales channels. Among them, explaining (share knowledge) research results to funding sources (e.g., venture capitalists, banks, angels, etc.) in an easy-to-understand manner is important because the organization cannot be formed without first obtaining funding.

The proposal in this study focuses on the first approach, technology transfer through collaborative research to existing companies. As mentioned above, the issue in the first approach is to reduce information stickiness, which is a disincentive for technology transfer of academia's research results to companies, and to ensure successful technology transfer and commercialization. Sako and Uchihira [4] used the Plan-Do-See (PDS) cycle to obtain a proof of concept (PoC) as a framework to analyze the success factors of technology transfer in collaborative research aimed at commercialization (hereinafter referred to as "commercialization collaborative research") that successfully transferred technology. This study uses a virtual case study to examine whether applying the analytical framework to project execution management when conducting joint research between industry and academia would reduce information stickiness and other impediments to technology transfer and promote technology transfer and commercialization of academia's research results.

In Chapter 2, we discuss previous studies that focused on the difficulties of knowledge transfer, particularly information stickiness, from the standpoint that technology transfer is a type of knowledge transfer. Chapter 3 defines PoC, a concept used as a framework for analyzing commercialization collaborative research. Chapter 4 describes the analytical framework that is used in this proposal. Chapter 5 presents a proposal for using the analytical framework in the management of collaborative research. Finally, Chapter 6 discusses a comparison with other approaches, a summary, and future issues.

2 Difficulties in Knowledge Transfer

Previous studies have pointed out the difficulty of technology transfer, or knowledge transfer, between two parties used in the first approach. von Hippel [5] stated that information transfer is costly because of the stickiness of the information. He also examined the factors that cause stickiness: the nature of the information itself (e.g., tacit knowledge), the amount of information (the larger the amount, the harder it is to transfer), and the absorptive capacity of the sender and receiver (e.g., background knowledge). He then presented the following four patterns as ways to reduce stickiness. (1) "When information needed for innovation-related problem solving is held at one locus as sticky information, the locus of problem-solving activity will tend to take place at that site." (2) "When more than one locus of sticky information is called upon by problem solvers, the locus of problem-solving activity may move iteratively among such sites as innovation development work proceeds." (3) "When the costs of such iteration are high, problem-solving activities that draw upon multiple sites of sticky information will sometimes be "task partitioned" into subproblems that each draw on only one such locus." (4) "When the costs of iteration are high, efforts will sometimes be directed toward investing in "unsticking" or reducing the stickiness of information held at some sites." R&D results in academia are difficult to technology transfer. The reason is that research results are highly adhesive information, such as tacit or champion data in a specific environment. Therefore, the four suggestions for reducing stickiness presented by von Hippel [5] can be used as a specific form of implementing collaborative research.

Szulanski [6] discussed stickiness, focusing on the difficulty of transferring best practices within the same company. Szulanski analyzed 122 cases of best practice transfer from eight companies and identified three reasons that hinder transfer. The first reason was the lack of absorptive capacity of the receiver, the second one was the lack of cause-and-effect relationships, and finally, the third reason was the relationship between the sender and receiver. Szulanski described difficulties in knowledge transfer of best practices within a company. However, it can be inferred that the same reasons affect knowledge transfer that takes place among different organizations and knowledge transfer, such as research results similar to those in the present study. For example, the research results of academia are often advanced, and the issue of the absorptive capacity of the transferring firm is likely to arise. In addition, research results are often champion data, as mentioned above. Moreover, although a certain causal relationship can be recognized, further research may be necessary to generalize the results. Furthermore, the direction of communication may be problematic between academia, which explores champion data, and companies, which need practical and reproducible data.

As described above, technology transfer from academia to industry is expected to be difficult in various aspects. Therefore, a method is needed to accurately convey knowledge in technology transfer among different organizations, especially in commercialization collaborative research. The analytical framework proposed by Sako and Uchihira [4] from the PoC perspective is examined for use in the management of commercialization collaborative research. In the next section, we define PoC, which is the basis of the framework in this paper with reference to previous papers.

3 Definition of Proof of Concept in This Paper

The term PoC is used in various fields these days. In general, PoC is used to describe the verification of a new idea in the context of venture creation, the verification of commercialization potential in the context of product development, the verification of the effectiveness of an IT system in the systems engineering context, and the verification of the efficacy of a drug in the drug discovery context.

Specifically, various prior studies defined PoC from a technical perspective. Thursby [7] defined the PoC stage of technology as "… universities are selling embryonic technologies. Such technologies are risky—there is a high failure rate—and faculty inventors are frequently involved in further development of the technology …." Narayan [8] defined the PoC stage as "At this stage intellectual property is created and needs to be protected by patent." Huston and Sakkab [9] defined the PoC stage as "It's basically creating experiments that demonstrate results." Rasmussen and Sørheim [10] identified PoC funds, which are spreading in Europe and the U.S., as funds that reduce the technological uncertainty of university ventures. Therefore, we believe that they argued that PoC is a process that reduces technological uncertainty. Thus far, PoC has been defined mainly as a verification of the feasibility of commercialization and practical application from a technological perspective.

In reality, however, even if a PoC is obtained in terms of technology, whether it can be commercialized in terms of business is a different discussion. In other words, PoC should be obtained in terms of business, such as whether there is a market, the market can be acquired, and the technology can sufficiently compete with alternative technologies. To this end, business hypothesis testing should be added to the PoC perspective rather than simply viewing PoC as technical proof. Sako and Uchihira [4] proposed a framework for analyzing commercialization collaborative research by dividing the conventional PoC into a proof of technical concept (PoTC) and a proof of business concept (PoBC). As this study discusses how the framework can be used not only for analysis but also for management of collaborative research, the details of the framework are explained in the next chapter.

4 Analysis of Collaborative Research using the Framework

Table 1 shows the framework proposed by Sako and Uchihira [4] (hereinafter referred to as "PoC framework"), which describes PoC in two main categories: PoTC and PoBC. The process of obtaining the PoC is described in terms of the PDS cycle. The PDS cycle is one of the most widely known approaches for organizations to manage their business activities. This cycle was proposed by Brown [11] in his book "*Organizational of Industry*". The PDS cycle is a method for organizations to manage projects through a cyclical process of plan, do, and see. In the planning phase (plan), goals are formulated; in the implementation phase (do), the goals are executed; and in the check phase (see), the results of the execution are evaluated and reviewed. In addition, there are columns for describing the state before and after the PoC process and for describing what information stickiness/asymmetry and resource gaps existed and how they were resolved in each state. The Sako and Uchihira [4] then states that by applying the PoC framework to the collaborative research conducted, how the commercialization collaborative research was advanced from the perspective of PoC and how the technology transfer among different organizations was resolved can be visualized.

Using the PoC framework, Sako and Uchihira [4] attempted to analyze two collaborative research projects, one on materials development (single-walled carbon nanotubes) and the other on voice processing (voice privacy technology). Of course, these R&D projects were not conducted with the PoC framework in mind. In the case of materials development, the stage of setting research goals corresponds to the planning stage of the PoC framework. In this stage, the business goals are set by the industry and academia (PoBC-P). Based on such goals, the breakdown of technical goals is made (PoTC-P), and the research is initiated. The issue in the execution phase of research (PoTC-D) is smooth knowledge sharing and knowledge transfer between industry and academia. As already mentioned, technical knowledge is sticky knowledge. Moreover, the organizations that share and transfer technical knowledge are different in nature and purpose. Using von Hippel's [5] suggestion of solving stickiness, Sako and Uchihira [4] analyzed that companies dispatched people to the academic side to solve problems in the same place, following the rule that "…when information needed for innovation-related problem solving is held at one locus as sticky information, the locus of problem-solving activity will tend to take place at that site."

Table 1: Proof of Concept (PoC) Framework [4]

		State of affairs prior to start of PoC (Issues, objectives, etc.)	PDS cycle during PoC			Direction after completion of PoC
			Plan	Do	See	
PoC Process	Proof of Technical Concept Process (PoTC)	(Pre-PoTC) Situation before the start of R&D. IP and IP Strategy.	(PoTC-P) Specific R&D plans, goals, and IP strategies to be undertaken during the PoC.	(PoTC-D) Status of R&D implementation and IP strategy implementation.	(PoTC-S) Evaluation at the end of R&D(e.g., attainment, discovery of new issues, etc.), and evaluation of IP strategy.	(Post-PoTC) Responses to technical issues after the completion of the project. Strategies for utilizing acquired IP.
PoC Process	Proof of Business Concept Process (PoBC)	(Pre-PoBC) Issues, goals, and potential needs derived from the market environment and other factors.	(PoBC-P) Hypotheses about specific concepts and business models for products and services based on latent needs.	(PoBC-D) The verification process for the hypotheses made.	(PoBC-S) Hypothesis testing results.	(Post-PoBC) Implement the business model or restructure or revisit the model.
Information asymmetry and information stickiness		Are there any information asymmetries among stakeholders or information that is sticky to a particular stakeholder before the PoC begins?				Status of resolving information asymmetries and stickiness prior to the start of the PoC.
Resource Gaps		Resource gaps seen among stakeholders prior to the start of the PoC.				Status of closing the resource gap that existed prior to the start of the PoC.

In the case of commercialization collaborative research on voice privacy technology, the company had a vague idea of the technology needed for commercialization at the goal-setting stage but was unable to discover it (PoBC-P). Through subsequent information exchange with academia, available technologies were clarified, roles were assigned, and research was initiated (PoTC-P), according to the analysis. In the execution phase of the research, the algorithm was expressed in the MATLAB programming language, which was used to exchange technical information between the industry and academia. This was analyzed as corresponding to the analogy of "when the costs of iteration are high, efforts will sometimes be directed toward investing in "unsticking" or reducing the stickiness of information held at some sites" in von Hippel's [5] suggestion of resolving information stickiness.

Thus, Sako and Uchihira [4] classified PoC into PoTC and PoBC and created a PoC framework that introduced the PDS cycle. They then analyzed collaborative research that was successfully commercialized using the framework. From another aspect, as to the applicability of the PoC framework to the commercialization collaborative research that is being conducted or will be conducted, they only stated that "...we believe that the framework can be used in terms of managing project implementation," and did not clearly state its effectiveness.

5 Proposal for Management of Commercialization Collaborative Research using a PoC Framework

Various frameworks have already been proposed for organizing, analyzing, and implementing issues in strategy development, marketing, and startup creation. For example, there are PEST analysis, SWOT/TOWS analysis, and positioning map for strategy and 4P for marketing. In addition, representative examples include the Business Model Canvas [12] for organizing ideas into business models and the Value Proposition Canvas [13] for understanding customers and organizing the value of the products and services offered.

However, as far as we know, there is no framework for managing collaborative research aimed at the commercialization of research results in academia. In this chapter, we propose to utilize the PoC framework of Sako and Uchihira [4] not only as an analysis tool but also as a management tool to promote the commercialization of collaborative research. Specifically, we propose to use the "PDS cycle during PoC" in the framework shown in Table 1 to manage the commercialization collaborative research. Figure 1 shows the parts of the PDS cycle of the framework in Table 1 in chronological order. The following sections will be explained according to the order shown in Figure 1.

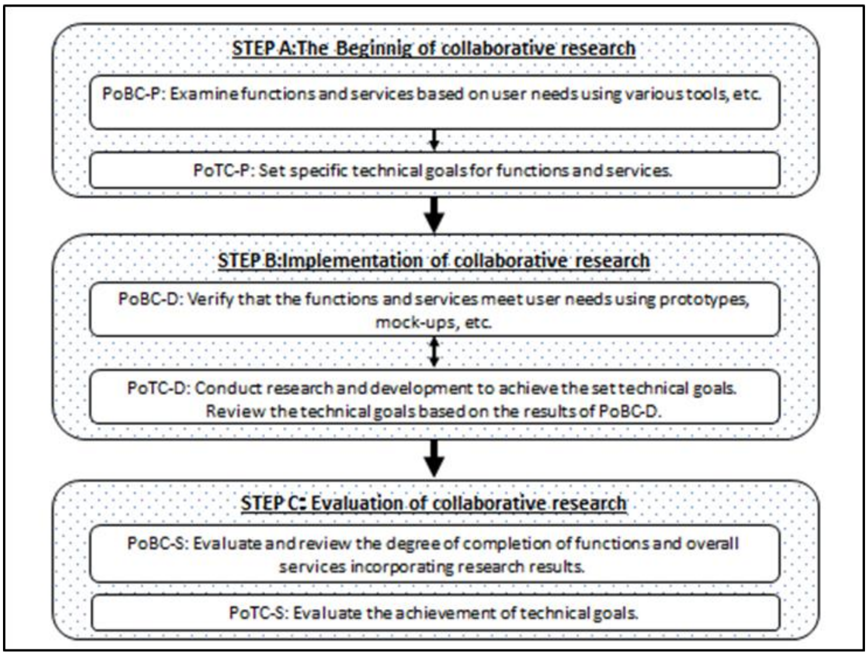

Figure 1: Management Process Using Plan-Do-See Cycle during Proof of Concept

(STEP-A) The beginning of collaborative research (PoBC-P, PoTC-P)

The PoC framework states that the PoBC-P column should describe "Hypotheses about specific concepts and business models for products and services based on latent needs." Therefore, when used for management, the PoBC-P column should be used to clarify what functions and features are required for the new product or service, starting from the user needs. This column should also be used to share this information among collaborative research partners.

As a virtual case, let us take the development of smart glasses with sensors to improve work fatigue. The assumption is that academia has research results on fatigue check algorithms using sensor information. The Value Proposition Canvas can be used to derive functions and features based on user needs (Figure 2). The problem that the customer wants to solve is the problem of eliminating fatigue from long hours of PC work. The customer's gains are understanding eye fatigue and knowing when to take a break efficiently, whereas their pains are that wearing glasses causes ear fatigue and other issues. The gain creators are a multi-functional sensor and fatigue check algorithm, whereas the pain relievers are the overall weight reduction and others. Therefore, the product will be the development of glasses with a sensor equipped with an algorithm to check for fatigue, and these will be described in PoBC-P.

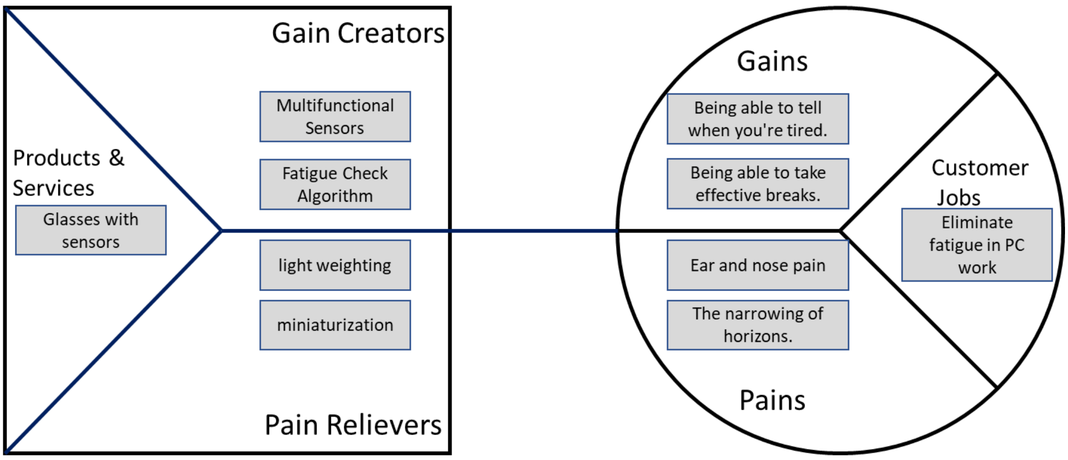

Figure 2: Value Proposition Canvas

The PoTC-P section is supposed to include "Specific R&D plans, goals, and IP strategies to be undertaken during the PoC." In other words, the technical target performance of the functions and features described in the gain creators and the pain relievers sections of the Value Proposition Canvas should be set, who will solve them should be considered, and they should be described and shared in PoTC-P.

In this case, clarifying who, how, and to what extent sensor performance, weight reduction, and fatigue check algorithms will be realized. For example, in the case of weight reduction, a target value can be set based on the weight of ordinary glasses, such as "50 grams including sensors." In the case of fatigue check algorithms, for which it is difficult to set target values, user satisfaction can be quantified through interviews and other means.

(STEP-B) Implementation of collaborative research (PoBC-D, PoTC-D)

The PoBC-D column will list "The verification process for the hypotheses made," and the PoTC-D column will list the "Status of R&D implementation and IP strategy implementation." In other words, this is the stage where R&D and business verification are conducted for each goal set in the goal-setting process.

In PoBC-D, mockups, prototypes, explanatory videos, and minimum valuable products are prepared and presented to clients and users to reconfirm market needs. In addition, the feasibility of the supply chain, such as the procurement of materials and the development of outsourcing partners, will be confirmed. The results of PoBC-D are fed back to the R&D conducted in PoTC-D. By reconfirming the needs, we can understand the user's tolerance level for functionality and performance, which allows us to revise the development elements or raise the target performance.

In PoTC-D, each organization will conduct its share of R&D for the specific goals set in PoTC-P. However, as mentioned in Chapter 1, as technology transfer across organizations is necessary for R&D, the information stickiness described by von Hippel [5] and Szulanski [6] should be resolved. They can be solved by following the pattern of four solutions indicated by von Hippel and by promoting commercialization collaborative research. For example, one solution is to have corporate researchers conduct research at a research location in academia. This corresponds to von Hippel's suggestion that "when information needed for innovation-related problem solving is held at one locus as sticky information, the locus of problem-solving activity will tend to take place at that site." Unlike technology transfer through documents, this method can also transfer the research content of academia, including background knowledge, to the researchers of the company, to which the research is being transferred, thereby contributing to improving absorptive capacity and solving communication problems. In addition, R&D items should be broken down into subtasks, and stickiness must be eliminated by having companies and academia conduct R&D in their respective areas and integrate them on a regular basis. This case corresponds to von Hippel's suggestion "when the costs of such iteration are high, problem-solving activities that draw upon multiple sites of sticky information will sometimes be 'task partitioned' into subproblems that each draw on only one such locus."

In this case study, the development of algorithms is done by academia, whereas the design of lightweight and miniaturization is done by the corporate side and others. In addition, approaches to resolve stickiness, such as involving company personnel in algorithm development, should be considered and implemented.

(STEP-C) Evaluation of collaborative research (PoBC-S, PoTC-S)

At this stage, monitoring is conducted to determine whether the R&D goals have been achieved and to monitor the degree of completion of the project as a whole by incorporating it into products and services. In particular, the final product at that point will be presented to the market and customers to receive feedback and the entire collaborative research project will be re-examined and prepared to go through the PoC process again.

Table 2 shows an example of the above when applied to Table 1 as a virtual case study of sensor-equipped glasses.

6 Discussion and Conclusion

This study proposed a method of utilizing the PoC framework proposed by Sako and Uchihira [4] for managing commercialization collaborative research and confirmed that the PoC framework has the potential to make a certain contribution. As the proposed method shows only procedural steps, incorporating other frameworks will be effective, including the Business Model Canvas and Value Proposition Canvas, as necessary at each stage of the PDS cycle in the actual management of commercialization collaborative research. In addition, considering various research findings on knowledge transfer, such as the tactics for reducing stickiness described by von Hippel [5], was found useful.

Table2: Proof of Concept (PoC) Framework Example (sensor-equipped glasses development)

		PDS cycle during PoC		
		Plan	Do	See
PoC Process	Proof of Technical Concept Process (PoTC)	(PoTC-P) ・Multifunctional sensor (company): Capable of sensing X elements simultaneously. ・Lightweight (company): within 50g ・Fatigue check algorithm (academia): 80% subject conformity. Patent pending on the method.	(PoTC-D) ・Algorithm R&D by academia and hardware development by companies.(Hippel-3) ・The company's researchers are stationed in the laboratory as visiting researchers in the development of the algorithm.(Hipple-1) ・Progress checks are conducted once every two weeks.(Hippel-2)	(PoTC-S) ・Development of sensor completed. ・Weight 50g achieved. ・82% conformity achieved.
	Proof of Business Concept Process (PoBC)	(PoBC-P) ・Development of glasses with sensors equipped with algorithms that can check for fatigue.	(PoBC-D) ・Mock-up display at a trade show. ・Interviews with opticians. ・Interviews with programmers and other heavy users.	(PoBC-S) ・50g is heavy.

There were several studies that tried to fill the knowledge gaps among stakeholders. The Internet of things (IoT) innovation design method proposed by Uchihira et al. [14,15] systematizes and utilizes several frameworks, including Business Model Canvas and Value Proposition Canvas to form a common understanding among stakeholders. This method is embodied in the SCAI graph regarding the use of IoT and artificial intelligence, but it focuses on IoT innovation and cannot be used for other fields (e.g., new product and service development for materials and devices). Suganuma and Uchihira [16] also proposed the UX design to bridge the gap between stakeholders in open innovation. They argued that although it is necessary to share knowledge of different industries among participating members to realize open innovation, it is difficult to share and understand knowledge sufficiently at the project planning stage, making it impossible to create specific requirements. Therefore, they proposed a method to study product development without necessarily having a mutual understanding of complex technologies by sharing user use cases among participating members and proceeding with the study. Although this method is not intended for commercialization collaborative research between companies and academia, it may be effective to use UX design to bridge the gap between companies and academia, depending on the stage and field of R&D. Therefore, it can be positioned as one of the approaches to be utilized in the PoC framework stage.

From another aspect, this proposal did not manage actual commercialization collaborative research between industry and academia using the PoC framework. Future research can verify the effectiveness of the PoC frameworks by using them in actual projects. Future studies can also organize the tools, frameworks, and research results used in each PoC framework stage. The possibility of using these tools, frameworks, and research results should be discussed while conducting actual projects. Furthermore, although this proposal is systematized with industry–academia collaboration in mind, it is also effective for open innovation, which is not limited to industry–academia collaboration, but specific studies are a future issue.

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References

[1] J. A. Schumpeter, Theorie der wirtschaftlichen Entwicklung (2. Aufl.), Duncker & Humblo, 1926. (The Theory of Economic Development, 1912, translated by R. Opie. , Harvard University Press, 1934.)

[2] P. Drucker, The Practice of Management, Harper & Row, 1954.

[3] M. E. Porter, Competitive strategy, The Free Press, 1980.

[4] T. Sako, and N. Uchihira, "An Analysis of Knowledge for the Commercialization of Research Results from the Perspective of Proof of Concept," Journal of the Japan Society for Intellectual Production, vol.17, No. 2, 2021, pp. 91-101 (in Japanese).

[5] E. von Hippel, " 'Sticky information' and the locus of problem solving: Implications for innovation," Management Science, vol. 40, no. 4, 1994, pp. 429-439.

[6] G. Szulanski, "Exploring Internal Stickiness: Impediments to The Transfer of Best Practice within The Firm," Strategic Management Journal, vol.17(Winter Special Issue), 1996, pp. 27-43.

[7] J. G. Thursby, and M. C. Thursby, "Industry/University Licensing: Characteristics, Concerns and Issues from the Perspective of the Buyer," The Journal of Technology Transfer, vol28, no.3–4, 2003, pp. 207–213.

[8] R. Narayan, "Commercializing Technology: A Case Study of Starch-Based Biodegradable Plastics Technology," Paradigm for Successful Utilization of Renewable Resources, vol. 78, 1998.

[9] L. Huston, and N Sakkab. "Implementing Open Innovation," Research-Technology Management, vol. 50, no. 2, 2007, pp. 21–25.

[10] E. Rasmussen, and R. Sørheim, "How Governments Seek to Bridge the Financing Gap for

University Spin-Offs: Proof-of-Concept, Pre-Seed, and Seed Funding," Technology Analysis & Strategic Management, vol. 24, no. 7, 2012, pp. 21–25.

[11] Alvin Brown, "Organization of Industry", Prentice-Hall,Inc., 1947.

[12] A. Osterwalder, and Y. Pigneur, Business model generation: a handbook for visionaries, game changers, and challengers, John Wiley & Sons, 2010.

[13] A. Osterwalder, Y. Pigneur, G. Bernarda, and A. Smith, Value proposition design: How to create products and services customers want. John Wiley & Sons, 2015.

[14] N. Uchihira, H. Ishimatsu, and K. Inoue, "IoT service business ecosystem design in a global, competitive, and collaborative environment," 2016 Portland International Conference on Management of Engineering and Technology (PICMET2016), 2016.

[15] N. Uchihira, "Innovation Design Method for the Internet of Things: Requirements and Perspectives," 2019 Portland International Conference on Management of Engineering and Technology (PICMET2019), 2019.

[16] T. Suganuma, and N. Uchihira, "UX-centric Design Method for Open Innovation," 2019 Portland International Conference on Management of Engineering and Technology (PICMET2019), 2019.