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Characteristic and Enlightenment on Universities Collaborative Innovation Mode of Japan Shikoku Area

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Abstract: Collaborative innovation, with universities as the main body, is an important foundation for deepening the cooperation between industry, universities, and research institutes. Taking the collaborative innovation of five universities in Japan Shikoku area as an example, this paper summarizes the content of collaborative innovation in colleges and universities. The Shikoku SICO, which is established by government, is set to integrate the resource of university, enterprises, industry, and government, expand and broaden the knowledge chain, and promote knowledge flow and value realization through knowledge gathering and diffusion, knowledge dissemination and sharing, and knowledge transfer and application. Based on SICO's collaborative innovation mode of the Japan Shikoku area, five universities have established a virtuous circle of knowledge, capital, and talents, forming a collaborative innovation ecosystem characterized by symbiosis. From an ecology perspective, this paper establishes a regional collaborative innovation symbiotic system, which is characterized by knowledge, with the components of producer, consumer, decomposer, and catalyzer. Finally, from the perspective of constructing symbiosis system, this paper puts forward the experience of colleges and universities in Japan in terms of knowledge dissemination, knowledge transfer, and knowledge gathering.

Keywords: university collaborative innovation; Japan; symbiotic; knowledge; enlightenment

1. Introduction

The concept of collaborative innovation was first proposed by Gloor, a researcher at the MIT Sloan Center in the United States. According to Gloor, collaborative innovation networks are "teams of people with a collective vision, who collaborate in achieving a common goal by sharing ideas, information, and work" [1]. From the perspective of collaborative innovation development history, it has experienced collaborative innovation from enterprises to collaborative innovation of industry–university–research, to collaborative innovation of universities with knowledge innovation as the core. The synergy of collaborative innovation in colleges and universities is more extensive, not only the synergy between the three parties of industry, university and research, but also the various forms of synergy between the internal disciplines of universities, universities and the connection of overseas universities. In addition, the mission of university is not only cultivating talents for the society and promoting the development of disciplines in universities, but also transforming productivity through knowledge innovation to promote regional economic and social development.

Recently, researches on collaborative innovation in colleges and universities is gradually increasing and academic communities begin to emphasize the innovation leading role of colleges and universities. He et al. [2] believe that the success of the Technical University of Munich (TUM) in Germany was to build an effective entrepreneurial education ecosystem. Wang [3] takes Stanford University as an example, pointing out that American university collaborative innovation focuses on the productive function of the university and attaches importance to entrepreneurship. The development of education

has made universities and enterprises form a unique mutually beneficial and win–win model. Lin [4] believes that the University of Tokyo, as a typical representative of collaborative innovation in Japanese universities, focuses on conducting basic research and emerging field research with enterprises. In addition to these research-oriented institutions, it cannot be ignored that a large number of local colleges and universities have achieved great results in the promotion of collaborative innovation, which is worth learning.

Collaborative innovation in Japanese universities is the core concept of "innovation ability improvement plan for colleges and universities", and the synergy between universities and industry is especially valued. "Industry–university integration" is regarded as one of the important ways to contribute to economic growth and technological innovation. The combination of industry and education in Japanese universities mainly includes two aspects. First of all, the university and the enterprise jointly carry out research activities, that is, industry–university integration with research process. Secondly, the research results of the university are directly transformed into technology and products are used by enterprises, that is, industry–university integration with research achievement. At the meantime, the Japanese government plays an important role in promoting the development of the combination of industry and education in universities. In 2012, the Ministry of Education, Culture, Sports, Science and Technology (MEXT) adopted the National University Reform and Intensification Promotion Program, and established a knowledge platform consisting of five representative national universities in the Shikoku area, namely Tokushima University, Kagawa University, Ehime University, Kochi University and Naruto University of Education. The basic information of these five universities are summarized in Table 1.

Table 1. Basic information for five universities in Shikoku area.

University	Year Founded	No. of Student	Specialty
Tokushima University	1949	7823	Engineering and scientific research
Kagawa University	1949	6426	Agronomy, medicine, economics, law
Ehime University	1919	9419	Basic education and application
Kochi University	1922	5584	Culture and education
Naruto University of Education	1981	1070	Educational theory and practice

The knowledge platform breaks through the boundaries between universities, effectively uses the existing resources of each university, integrates Admissions Office (AO) entrance exams, and e-learning education sharing to promote collaborative innovation. This is a typical case of Japan's collaborative innovation in universities, and it has exerted the innovative power of local universities. Therefore, this paper takes the collaborative innovation of five universities in Japan Shikoku area as an example to explore how to construct a collaborative innovation ecosystem with colleges and universities as the main body and characterized by symbiosis, in order to provide experience for the promotion of collaborative innovation in universities of other countries.

2. Contents of Collaborative Innovation in Universities of Japan Shikoku Area

2.1. Promote the Platform Construction of Knowledge Innovation

The Shikoku Innovative and Collaborative Organization (SICO), a collaborative innovation and promotion organization for Japanese universities, was established by the Japanese government, with headquarters in Tokushima University and satellite offices in other four universities. The SICO annual implementation plan [5] is shown in Table 2.

Table 2. Shikoku Innovative and Collaborative Organization (SICO) implementation plan.

Year	Implementation Plan
2012	Goal: Preparation for SICO establishment Goal: Improve SICO infrastructure
2013	(1) Setup regulation (2) Operation system establishment Goal: SICO typical project execution and validation
2014	(1) Exploring the cooperation mechanism with Technology Licensing Organization (TLO) (2) Work with the heads of universities to build an efficient operating mechanism Goal: Full operation and commercial verification of the SICO
2015	(1) Strengthening the synergy mechanism between SICO and universities (2) Piloting the collaboration mechanism with TLO Goal: The full operation of the industry–university cooperation
2016	(1) Talent enhancement of SICO (2) Transfer of common business (3) Synchronization with TLO
2017	Goal: As an industry–university research collaboration agency to international development

From the establishment and function of SICO, the collaborative innovation model of five universities in the Shikoku area is a collaborative innovation model of universities under the guidance of the government. With the support of government, universities take the lead and strengthen the connection between universities and enterprises, governments and markets to achieve knowledge agglomeration and diffusion, knowledge dissemination and sharing, and knowledge transfer and application.

The process of collaborative innovation is to integrate innovative resources, to manage innovative resources and to export innovative resources, and eventually to establish a virtuous circle of talents, knowledge, and capital in this process, and to constantly improve and optimize the synergy of each subject. With the university as the knowledge hub to maximize the value of knowledge, the key to collaborative innovation is how to balance the "complementarity-differentiation" of each subject and the "cost-efficiency" dynamic equilibrium of outputs. The architecture diagram of the five universities collaborative innovation in the Shikoku area is shown in Figure 1.

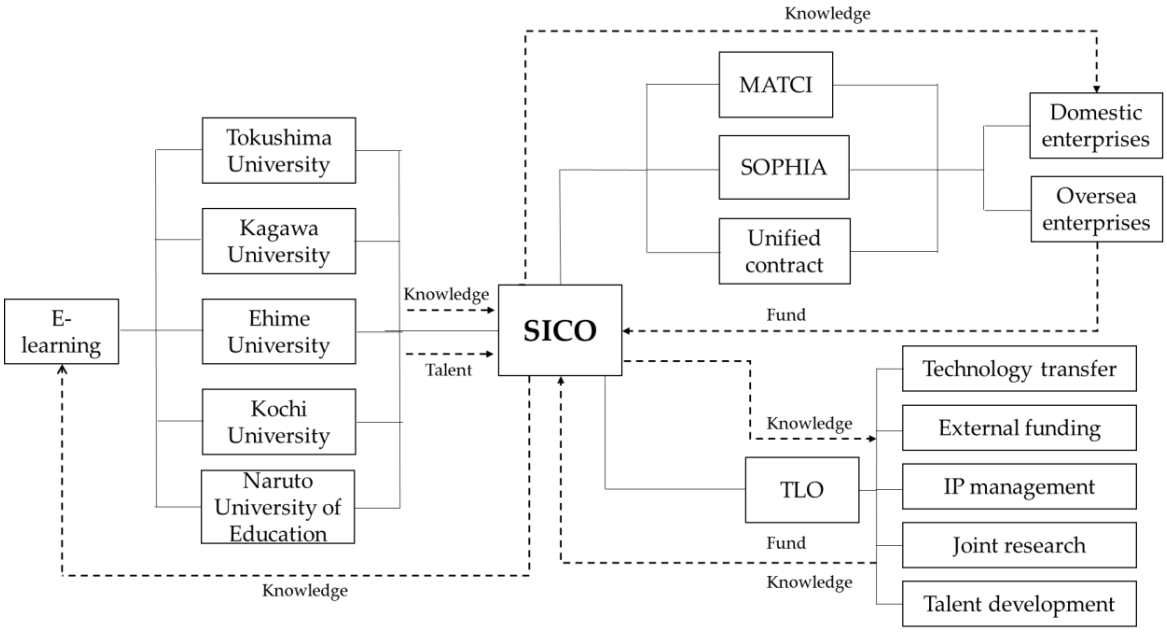

Figure 1. SICO platform for universities collaborative innovation in Shikoku area.

There are three flows in the collaborative innovation process, namely knowledge flow, talent flow and fund flow. In order to start the process, on the one hand, SICO would first get knowledge and talent from the five universities in Shikoku area. Then the knowledge will be effectively transferred to external enterprises, including domestic and oversea ones, via solid tools such as MATCI, SOPHIA and unified contract which are dedicated developed to connect resource in Shikoku area. On the other hand, SICO will proactively to work with Shikoku TLO to decompose knowledge in different forms, such as joint research and IP management. As a result, after enterprises and TLO gain benefit, the fund will flow into SICO and universities eventually. Furthermore, based on the learning collection from enterprises, SICO engages with universities on "E-learning" system, which is a knowledge platform for the cooperation of the five universities in Shikoku area. The "E-learning" focuses on content such as industry–university–research collaboration and entrepreneurship. In this way, the knowledge flows in a virtuous circle in the collaborative innovation process.

2.2. Promote Knowledge Flow and Value Co-Creation Realization

With the guidance of the government, the collaborative innovation of colleges and universities in the Shikoku area is joint promotion of common business. The collaborative innovation, which emphasizes the leadership role of colleges and universities, is characterized by knowledge flow and value added. With concept of "value co-creation", the collaborative of Shikoku universities, enterprises, research institutes and governments have realized various innovation elements with knowledge as the core elements. The collaborative innovation of universities with value co-creation perspective realizes the loop of "marketing demand generation–innovation knowledge input–innovation ability enhancement–value output–new marketing demand generation". This process enhances the ability of each collaborative participants to innovate in knowledge flow, especially on knowledge agglomeration, knowledge transfer, and knowledge dissemination.

2.2.1. Focus on Knowledge Agglomeration

The universities in Shikoku area have their own characteristics. In order to concentrate the superior information of each university and build a knowledge agglomeration platform, which is easier for enterprises to search for the required research technical information and seek technical matching, SICO develops and starts using "Matching System for Academia Technology Collaboration with Industry (MATCI) [6]. The "MATCI", which brings together the results of university researchers, is a Web system that links new business opportunities with industrial development, aiming to match the university's research results with the needs of the company. Actually, it is a database with no system registration fees and usage fees to facilitate technology matching by searching for scientific and research technology information required by other organizations, and can be associated with joint research and new business development. After logging in to the system, the user can make an appointment with the researcher and conduct an interview directly. As of March 2018, there are more than 3000 scientists and researchers connected in the MATCI system, and the system included a total of approximately 13,985 research technical information (research paper, literature, patent, etc.) from five universities, and 21 joint research contracts have been established to date.

Furthermore, in order to build a unified information collection and management application system in the four countries, SICO established the franchise management and technology transfer management system "SOPHIA", which is known as Total Patent Management System. By introducing the system, each university can manage the information about intellectual property in a unified manner separately, and input remote information through the cloud service to improve management convenience. Not only intellectual property management, but also contract and license revenues can be managed in the system.

2.2.2. Strengthen Knowledge Transfer

SICO is committed to closely link the research results and intellectual property of universities with the actual needs of the industry. SICO actively seeks to align with the business of Techno Network Shikoku Co., Ltd. (Shikoku TLO), and efficiently utilizes and manages the use of knowledge resources, and promotes joint research and commissioned research. TLO was established on 15 February 2015 through the efforts of volunteers from the teachers in 5 universities of Shikoku area. Shikoku TLO carries out a wide range of activities including three major forms: (1) License agreement for patent commercialization of universities; (2) joint research with university and company researchers; and (3) provide companies with research results (materials) from university researchers, under the Material Transfer Agreement (MTA). The synergy between SICO and TLO is mainly reflected in the following aspects: One is to jointly carry out technology transfer (such as patents) activities with universities; the second is to jointly explore the cooperation of regional enterprises; the third is to participate in overseas technology transfer activities.

Through technical support, technical cooperation, and technology transfer, the parties will cooperate to carry out technological innovation activities and obtain social benefits. For example, SICO and TLO work with Shikoku dairy industry companies to co-invented anti-allergic "N plus" products, and with the continuous support from researchers in universities, the new product quality improved a lot and achieved bigger market share. At the same time, the university researchers can receive patent authorization fee in a loyalty business mode. Besides, SICO is also actively involved in the cooperation of overseas technology transfer agencies. Among the overseas technology transfer agencies, a diplomatic memorandum on technology transfer was concluded through Shikoku TLO.

2.2.3. Promote Knowledge Dissemination

The SICO seeks to establish links between knowledge providers and knowledge demander, and spread the knowledge and technology of five universities in Shikoku area to the industry, so that more people can share the knowledge and become potential knowledge applicators. With efficient and high-level activities, the SICO established a practical industry–university–research collaborative operation mechanism. In addition, since 2013, SICO has started collaboration with E-learning, which is a knowledge platform in the five universities, so that it can fan out industry–university–research collaboration and entrepreneurship in Shikoku area. At the same time, SICO will jointly implement university education in the "Cooperative Concept of Five National Universities in the Four Countries", share the quality education resources of each university, and strive to improve the quality of education in all partner universities.

2.3. Play the Role of Government Boost

In order to promote the transformation of scientific research achievements, talent development, discipline construction and technological innovation in universities, the Japanese government has introduced a series of policies [7] for supporting, continuity and operability, and to promote interactive cooperation and talent training for industry, university and research [8]. The Japanese government pays particular attention to the construction of an innovation ecosystem. The "Innovative Ecosystem-based Collaborative Innovation Strategy for Industry University and Government" [9] was established by MEXT in 2010, to create a sustainable and innovative ecological environment that is conducive to cooperation. This innovation strategy includes several elements such as talent, fund, and knowledge. The specific measures of the new strategy are reflected in four aspects: one is to establish a collaborative innovation platform for industry–university–research cooperation, the second is to build a cooperation network between universities and research institutions, TLO, financial institutions and other related innovation entities, and the third is to cooperate with intellectual property protection funds to promote the transformation of university scientific research achievements, and the fourth is to strengthen the cultivation of industry–university–research collaborative innovation service talents.

These measures have played a positive role in building a good collaborative innovation environment for industry–university–research cooperation. In the past decades, with the government boost, Japan universities worked together with enterprises and research institutes to actively participate in leading technology industry, specifically in the following aspects: Super lattice component, carbon nanotube, cyan LED, optical fiber, and conductive plastic. With the universities research ability and core patent, some techniques have achieve good performance and demonstrate strong market potential. For example, Nagoya University had been working with T Company to develop new generation of cyan LED in lighting industry, and boosted the revenue with more than three times from 1997 to 2005 [10].

Table 3 is the main legal policies [11] formulated by the Japanese government to promote collaborative innovation in universities in the past 20 years.

Table 3. Universities collaborative innovation in promotion by Japan's government.

Year	Legal Policy
1998	The Graduate School of Frontier Sciences (GSFS)
1998	Technology Licensing Organization (TLO)
1999	Special Act for industrial vitality regeneration
2000	Industrial Technology Competitiveness Enhancement Act
2002	Basic law on intellectual property
2003	National University Corporation Law
2006	Education Basic Law Amendment
2008	Cutting-edge innovation base
2010	Collaborative Innovation Strategy of Industry, University and Research Based on Innovation "Ecosystem" Construction
2011	University commercial secret management guidelines
2012	Leadership Development Action Plan
2013	Strengthening the Industrial Competitiveness Law
2014	Legal changes to promote the transfer of university scientific and technological achievements to private enterprises
2016	Human Resources Development Cooperation Industry-University-Research Cooperation Action Plan
2016	Strengthen the guidelines for cooperation research between industry, universities and research institutes
2017	Formulate a talent supply and demand working group plan
2018 *	Setup mid-term goal and plan for university and company joint research

* Summarized from MEXT (Ministry of Education, Culture, Sports, Science and Technology) website.

3. University Collaborative Innovation Characterized by Symbiosis

3.1. Collaborative Innovation Symbiosis Model

For symbiosis system, previous researches mainly focus on industrial symbiosis [12,13], environmental symbiosis [14] and urban planning [15]. The symbiosis system for university collaborative innovation is seldom studied. The five universities in Shikoku area have established a collaborative innovation model characterized by symbiosis with close cooperation and mutual promotion with enterprises, intermediaries, financial institutions, and government departments.

3.1.1. The Composition of the Symbiotic System

As shown in Figure 2a, the university collaborative innovation symbiotic system consists of four basic elements: Symbiotic unit, symbiotic matrix, symbiotic interface and symbiotic environment [16]. In the collaborative innovation ecosystem of the five universities, the symbiosis unit is composed of universities, enterprises, research institutes and other entities. By constructing symbiotic matrices such as technology transfer, talent exchange, and financial support, it provides complementary resources for the symbiotic unit. SICO, which is an innovation platform established by the government, is the medium, channel or carrier of knowledge, talent and fund transmission between the symbiotic units. As the symbiotic interface, SICO is the basis for the formation and development of the symbiotic relationship, and is the core element that determines the efficiency and stability of the symbiotic system. The evolution of the system is inseparable from the effective boost of the government. The government provides a good symbiotic environment and promotes the interaction of symbiotic units.

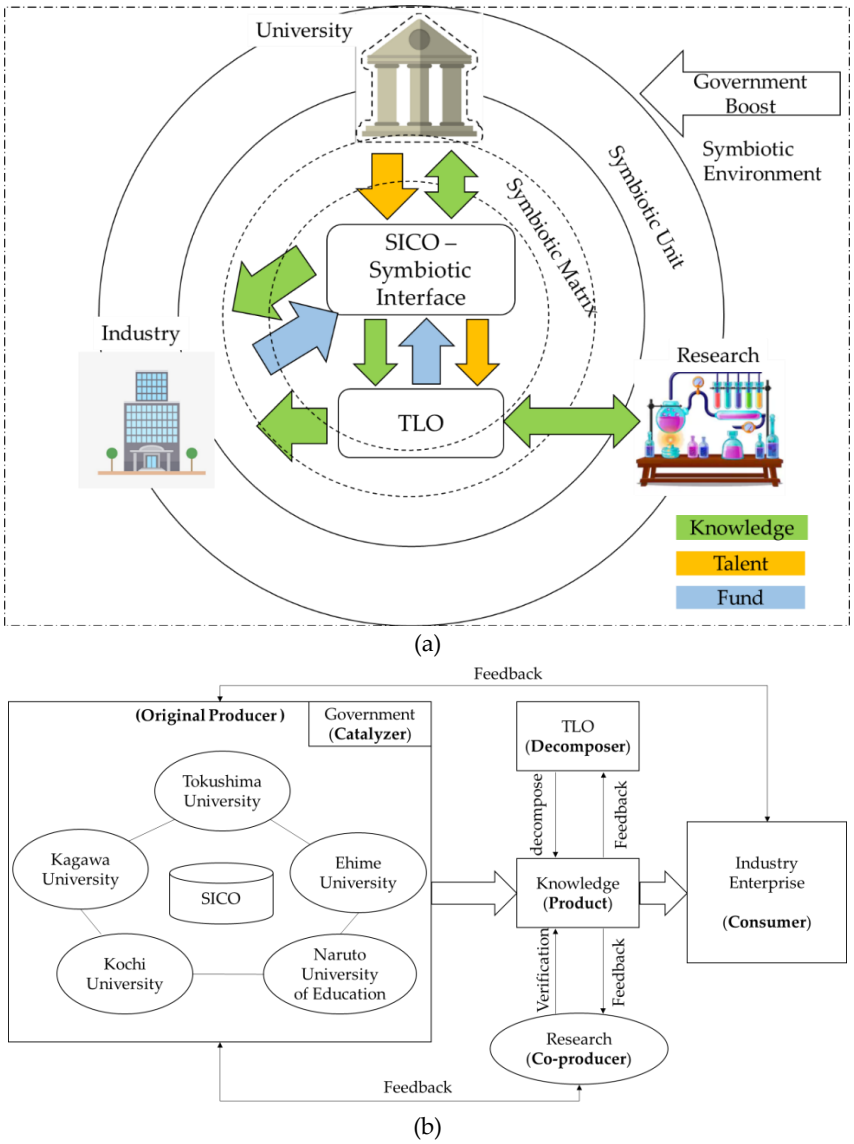

Figure 2. University collaborative innovation characterized by symbiosis in Shikoku area from two perspectives: (**a**) Symbiotic system; (**b**) symbiosis role.

3.1.2. The Mechanism of the Symbiotic System

In 1996, Grant proposed a more systematic "knowledge-based enterprise theory" [17], and then the "knowledge value chain" theory based on Porter's value chain theory [18–20]. These theories hold that enterprises are the integrated institutions and user of knowledge, and knowledge is the key to the acquisition of competitive advantage and the most fundamental source of heterogeneity. As shown in Figure 2b, the collaborative innovation symbiotic system setup in Shikoku area is an integral system, including producer, catalyzer, decomposer, and consumer. In the symbiotic system, the five Shikoku universities are knowledge producers with the promotion from SICO, which is an organization established by the Japanese government. The SICO acts as central organizer with five universities in the collaborative innovation symbiotic system, and the government performs as a catalyzer to boost the knowledge producing process. The Shikoku universities are working closely with research institutes to produce product, which is knowledge in the symbiotic system, and with the decomposing from TLO, the enterprises and industry organizations can easily digest and consume. In the end, in order to form a close loop, the enterprises will feedback to universities including contents such as knowledge application in enterprise, entrepreneurship e-learning online course, etc.

As a symbiotic interface for collaborative innovation systems in universities, SICO aims to improve the overall operational efficiency by organizing and consolidating repetitive tasks related to the cooperation activities of the five universities, and actively strengthen cooperation with enterprises, research institutes and intermediaries to promote innovation and further use of research results in Shikoku area. Relying on the high efficiency symbiosis interface, the symbiotic unit forms a comprehensive cooperation, builds a stable and fair integrated symbiosis system. Talent cultivation, knowledge emergence, capital growth, etc., continuously provide symbiotic energy to the system, promote the transformation of the symbiotic type to a more superior symbiosis, and eventually realize the symbiotic evolution.

3.2. Symbiotic System Innovation Performance

The five universities in Shikoku area have established cooperative and mutual assistance mechanisms with enterprises, research institutes and intermediaries, which promoted the benign coordinated development of the symbiotic unit and truly realized the inter-regional symbiosis. The good performance can be observed from three aspects: First, the resource bottleneck of the symbiotic unit is reduced or eliminated. The five universities in Shikoku area can share courses with each other via E-Learnings. By making appointment in MATCI system, the local enterprise staff can access universities laboratory. Secondly, the symbiotic system of virtuous circle is established. The industry–university–research cooperation in Shikoku area runs in a close loop with virtuous cycle of knowledge-talent-fund. For example, Tokushima University and Awa Bank have signed a cooperation agreement to improve the profitability of small companies in the county through knowledge transfer, and contribute to local industrial revitalization. Thirdly, is to reduce or diversify the risk of innovation. The innovation cooperation is highly market orientated which is initiated by industry and enterprises. The oriented innovation reduces risk, and achieves better result. Take the cooperation with oversea organizations as example, SICO actively participates in the cooperation of overseas technology transfer agencies through TLO. Since 2015, there are several oversea cooperation that successfully executed, such as contracts with organizations like Future Venture Capital Americas, Intellectual Property Intermediary Singapore, and PlaTCOM Ventures Malaysia. The symbiotic system based on the market-led mechanism further promotes the overall competitiveness of the system. For example, the synergy between SICO and TLO has led to the continuous development of collaborative innovation activities in universities. The total amount of revenues from patent implementation in the five universities was 16.566 million yen in the initial operation in 2012, and 123.832 million yen in 2016, increasing approximately 7.5-times [21], as shown in Figure 3.

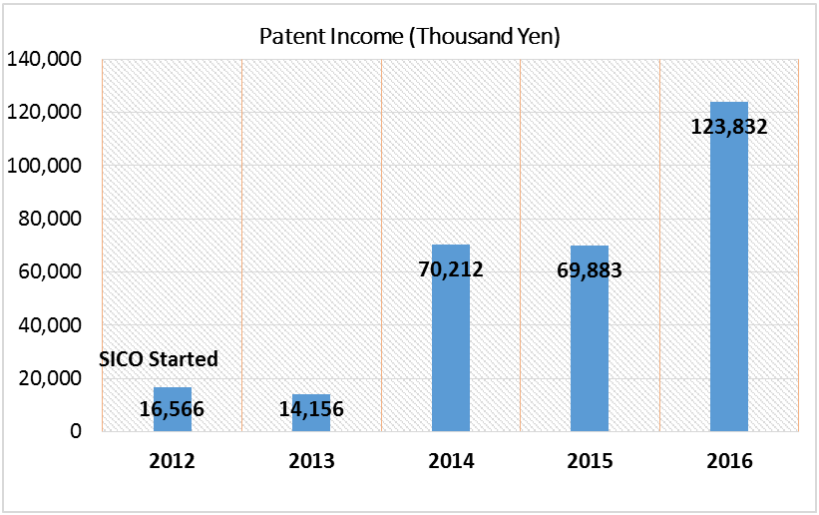

Figure 3. Five universities patent income since SICO started in Shikoku area.

4. Value Co-Creation of Symbiotic System with Knowledge as Core

The development of collaborative innovation activities in Japan Shikoku universities profoundly embodies the value co-creation process of multiple innovative subjects. On the one hand, universities, SICO and research institutes, as knowledge providers, can realize their own scientific and technological innovation capabilities through internal and external synergy, and promote the cultivation of talents and the development of disciplines; on the other hand, enterprises as technological demand parties, they can obtain the scientific and technological innovation resources needed to accelerate the transformation of scientific and technological achievements into innovative products. In addition, the boosting role of government departments accelerates the value co-creation of synergistic symbiosis among various innovation entities and promotes economic and social development.

Based on the learning from Shikoku universities, the value co-creation process of collaborative innovation in universities is mainly completed in four steps. The first step is the generation of demand. Collaborative innovation in universities is continuously spiraling upwards under the cooperative development model of enterprise participation and government promotion. Its innovation activities must be oriented to the needs of scientific frontier research, facing the needs of major national special tasks, and the needs of industrial development. The second step is the input of innovative elements. Universities and research institutes mainly invest in talents, knowledge, technology and other resources. In Shikoku, all the five universities are supportive to provide talent to participate in joint research, e-learning, etc. As return, they can get technology, capital, policies and funds from enterprise and government. The third step is the improvement of innovation ability. Under the concept of "value co-creation", the boundaries of each innovation subject are continuously broken, and intellectual capital and economic capital are continuously transformed, so that the innovation ability of each innovation subject can be improved. For example, SICO will bring the learnings back and share with universities through "e-learning" platform. The fourth step is the value of output. The disciplines of colleges and universities have been developed, and a number of talents with innovation and entrepreneurship have been cultivated. The ability of scientific research and innovation has been improved. Research institutes have also improved their scientific research personnel training and scientific and technological innovation capabilities, and enterprises have accumulated a number of scientific and technological innovation resources. It has promoted the transformation of scientific and technological innovation resources into innovative products, thereby promoting economic and social development. As the headquarters of SICO, Tokushima University established the Tokushima Regional Cooperation Research Center. The center focuses on four areas of strategic promotion in Tokushima: LED, energy, food processing and aquaculture. During R&D and innovative technologies promoting, the university trained many senior technicians, which greatly enhances the competitiveness of companies in Tokushima.

Based on the value co-creation, universities collaborative innovation with knowledge as core content presents three distinctive characteristics as follows:

(1) Break the boundaries between innovative subjects. In the process of transformation of results, enterprises can quickly (e.g.,: MATCI) integrate university science and technology resources by leveraging the advantages of being close to the market and accurately grasping the current and future technological needs of the market. Universities as producer in symbiotic system to provide knowledge and talent for the entire collaborative innovation process for companies and intermediaries to absorb. Collaborative innovation in colleges and universities promotes the integration of production and education, the cooperation between schools and enterprises [22], and the values co-creation makes the boundaries between subjects gradually blurred. With the help of government policies, universities and enterprises collaborate to achieve personnel training and scientific research. The scientific and technological research of enterprises extends to universities, and the knowledge creation and high-quality talents of colleges and universities are digested and absorbed in enterprises, thereby continuously promoting the development of enterprises and activating the vitality of the market.

(2) Realize the unity of knowledge creation and demand. In the value co-creation of collaborative innovation in Shikoku area, it is driven by both consumer and producer. The development mode shifts from single subject orientation to value symbiosis orientation. Universities and enterprises are the core participants of value co-creation, focusing on social economic development, industry upgrade needs, talent cultivating and scientific research improvement in universities. In terms of realizing the unity of knowledge creation and demand, the universities collaborative innovation is targeting to create benign operation cycle of "demand generation–innovation factor input–innovation ability enhancement–value output–new demand generation" [23] and cyclic evolution.

(3) Realize the value added of knowledge. Knowledge is a necessary and important resource in the process of collaborative innovation in universities. As a carrier of knowledge, universities are responsible for knowledge selection, knowledge absorption, knowledge integration, knowledge transformation, and knowledge innovation, and promote the flow of knowledge infinite loop. In the flow of knowledge, based on needs from scientific frontier research and industry development, universities absorb and integrate scientific research results, conduct interdisciplinary scientific research, develop innovative entrepreneurship education, and build a collaborative innovation platform. On the one hand, it promotes the flow of knowledge such as knowledge agglomeration, knowledge dissemination, knowledge transfer, and interdisciplinary new knowledge. On the other hand, it promotes the absorption of innovative knowledge by enterprises, thereby continuously creating new knowledge and turning knowledge into products or services [24]. The transformation of knowledge realizes the value added of knowledge.

5. Discussion and Enlightenment

By learning the collaborative innovation cases of five universities in Japan Shikoku area, we established collaborative innovation operation flow and symbiotic system with knowledge as core. We can find that the collaborative innovation of Japanese universities is inseparable from the promotion and guidance of the government. SICO, which is established by the government, closely links the resources of universities, their own platforms and technology transfer institutions, so that a virtuous circle of knowledge, talents and fund is formed, and construct a collaborative innovation ecosystem of universities with symbiotic characteristics. Furthermore, the Shikoku universities symbiotic system, in which knowledge is produced, decomposed and consumed, keeps driving value co-creation for all participants and promote regional development. Besides the case of Tokushima University mentioned in chapter 4, there are real cases for other universities. SICO has been engaged with Kochi University and local enterprises in housing industry. The steel frame WAWO (Welding for Anti-Wave Obstruction) method based on the cooperation of industry, university and research institute is a technical framework dedicated to the development of high-quality earthquake-resistant housing in Kochi area. A venture capital firm "ACREATE" has been established and its proprietary technology is being sold. In Ehime, the aquaculture industry is booming, such as salmon and yellow croaker. At the same time, the development of the aquaculture industry has also brought about some problems, such as aquaculture polluting the ocean. Through the research results of Ehime University, an advanced breeding technology for the future has been developed, so that the industry can achieve long-term healthy and green development in the local area.

Through the summary of its mode, the following four enlightenments can be obtained.

5.1. Improve the Influence of Symbiotic Units from Knowledge Dissemination

Japanese universities pay attention to building a loop of knowledge feedback. In the process of cooperation with enterprises and TLO, SICO collects many valuable contents including the technology applications in enterprises, the industry–university–research collaborative examples from each university and the entrepreneurship in local region, then cooperate with five national universities in the Shikoku region to implement university education and improve the quality of education in all partner universities through the "e-learning" platform.

In the process of collaborative innovation in colleges and universities, knowledge dissemination is a process in which the knowledge of colleges and universities flow and spread among their internal individuals or organizations. Colleges and universities play a pivotal role in knowledge dissemination. According to the SECI (Socialization, Externalization, Combination, Internalization) model, knowledge communication specifically includes four specific paths of socialization, representation, internalization and linkage of knowledge [25]. The promotion of knowledge dissemination plays a very important role in the cultivation of talents in the process of collaborative innovation. Talents, as the creators and carriers of knowledge, can promote knowledge flow and value-added. Drawing on the experience of knowledge dissemination in the five universities in Shikoku area, following enlightenments can be draws for the colleges and universities administrators: (1) It is important to construct a loop of knowledge feedback, and timely forward the knowledge generated in the process of collaborative innovation to universities to serve the talent cultivation of colleges and universities. (2) It is necessary to start from both inside and outside of the university to establish a high-quality entrepreneurship education system and pay attention to the cultivation of innovative entrepreneurship in college and university campuses. (3) In order to build an "ecological, full-chain" innovation and entrepreneurship education network, it is not only rely on the development of campus resources, but also through technology transfer institutions, entrepreneurial research organizations, etc. to assist and incubate entrepreneurship, so that entrepreneurship education is supported by technological innovation and market demand.

5.2. Promote the Flow of Symbiotic Matrices from Knowledge Transfer

In terms of knowledge transfer, five universities in the Shikoku area under the guidance of SICO and the synergy with TLO have made good progress for industry–university–research activities, promoted the transfer and application of knowledge, expanded the channels of technical cooperation, and increased the funds of colleges and universities, and eventually greatly promotes the flow of the system's symbiotic matrix. Recent research [26] shows that the number of patent applications, grants and patent holdings in China's colleges and universities far exceeds that of Japanese universities, but due to the low technological content of patent activities in China's universities, the lack of technology transfer service institutions and specialized management talents, plus the patent regulations and policies are not perfection, etc., the knowledge transfer ability of Chinese universities is seriously restricted.

As the producer of knowledge, colleges and universities in the process of collaborative innovation increasingly need to transform knowledge results through knowledge transfer, so that knowledge can be transformed into an intellectual property. Through the interaction with industry, the universities would get high returns from those intangible capital. Therefore, in the process of collaborative innovation in colleges and universities, knowledge transfer ability is an important factor affecting the performance of collaborative innovation. Learning from the experience of knowledge transfer in the five universities in Shikoku area, the colleges and universities administrators should pay attention to the following aspects: (1) It is critical to establish a good channel for the transformation of scientific research achievements, give play to the role of university technology transfer centers, and strengthen cooperation with local technology transfer agencies. The transformation of results provides professional services, stimulates the enthusiasm of patent technology transfer in colleges and universities, and raises the level of patent income of colleges and universities. (2) It is necessary to setup professional institutions to provide services for entrepreneurs, and complete technical and market assessments to help entrepreneurs implement startup business plans, and achieve technology transfer in this process.

5.3. Strengthen the Cohesion of the Symbiotic Interface from Knowledge Agglomeration

The five Japanese universities have created the "MATCI" as the industry–university–research support matching information system to realize the knowledge agglomeration and unified management of colleges and universities. With MATCI system, it is easier to promote the university to meet the enterprise by enhancing knowledge management in colleges and universities, improving the

information transparency of university technology, and simplifying the technical cooperation process of schools. The system can effectively deal with the communication between SICO and various elements within the system, and fundamentally enhance the concentration of the symbiotic interface.

Collaborative innovation in colleges and universities takes universities as the source of knowledge, but it is not enough to rely solely on the knowledge of universities. Collaborative innovation in universities must effectively integrate the knowledge resources of scientific research institutes, enterprises and overseas scientific research forces. The accumulation of knowledge is not simply a process of bringing together knowledge, but a process of recombining or creating new knowledge of complementary knowledge resources of adjacent innovation entities in geographic or social relationships. Obviously, the ability of knowledge agglomeration is an important factor to improve the performance of collaborative innovation in colleges and universities. Drawing on the experience of universities in Japan in terms of knowledge agglomeration, the colleges and universities administrator should pay attention to the following enlightenments: (1) Make accurate assessment to self-strengths, characteristics, and regional conditions, it is important to adopt appropriate methods to gather the technical achievements of colleges and universities, and realize the platform for knowledge gathering and creation, information collecting and sharing. (2) Pay attention to the internationalization of colleges and universities, strengthen international exchanges and cooperation, explore multi-form cooperation models, and broaden the scope of knowledge gathering.

5.4. Promote the Formation of Collaborative Innovation and Symbiosis System from Government Boost

The collaborative innovation of the five universities in Shikoku area is inseparable from the support of the government. The government strongly supports to build a symbiotic system, and plays a key role in promoting institutional innovation, maintaining the vitality of technological innovation, and promoting the construction of collaborative innovation and symbiosis systems in colleges and universities.

As a policy maker, the government provides financial support and provides policy support for the smooth development of collaborative activities for colleges and universities, and plays a role as a booster for promoting collaborative innovation in universities. Therefore, the government's external boosting ability is an important factor affecting the collaborative innovation of colleges and universities. Drawing on the experience of the Japanese government in promoting collaborative innovation in universities, the following enlightenments are learned: (1) By enacting relevant laws, regulations, and policies, government can provide guidance to symbiotic units such as universities and create a symbiotic environment conducive to the innovation and development of colleges and universities. (2) Government should encourage financial institutions and technology transfer institutions to actively support university science and technology innovation services, increase policy support for the transformation of scientific and technological innovation achievements, improve financial services, and build a symbiotic matrix of "knowledge-talent-fund" benign cycle. (3) It is necessary for government to work together with universities to promote the establishment of diverse and innovative knowledge platforms to form an efficient and stable symbiotic interface.

6. Conclusions

Collaborative innovation in Japanese universities has greatly promoted the cooperation of industry, university and research. It is an important part of the national innovation system and has created the glory of Japan's semiconductor, household appliances, automobile, and other industries. University collaborative innovation is an important experience model for Japan to achieve economic take-off after the war [27], and it has been learned by many countries.

As for universities collaborative innovation, there are many good cases from top universities, such as TUM, which is focusing more on startup business and entrepreneurship, and Stanford University, which is innovation center for Silicon Valley enterprises. The case in Shikoku area, however, is a little different since these five universities are all regional ones and not top universities in Japan.

The synergy between ordinary universities creates much bigger value than the total value that each individual university can provide. The government of Japan Shikoku area established the SICO under the guidance of the National University Reform and Strengthening Subsidy Program, which promoted the collaborative innovation of five universities in the region and established a collaborative innovation ecosystem with symbiotic characteristics. In this ecosystem, colleges and universities as the producers of knowledge, together with enterprises and research institutes, form a symbiotic unit. Through the efficient and stable symbiotic interface SICO, and under the promotion of effective government policies, a good symbiotic environment is formed and the virtuous circle of knowledge, talents and capital is established, thus maintaining the fluidity of the symbiotic matrix and the self-supply of symbiotic energy, and finally achieving the evolution of symbiosis.

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Abbreviations

SICO	Shikoku Innovative and Collaborative Organization
TUM	Technical University of Munich
MEXT	Ministry of Education, Culture, Sports, Science and Technology
AO	Admissions Office
MATCI	Matching System for Academia Technology Collaboration with Industry
TLO	Technology Licensing Organization
GSFS	Graduate School of Frontier Sciences
MTA	Material Transfer Agreement

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