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Analysis and Practical Applications of University-industry Research Collaborations

Kazumasa Kawasaki

Department of Mechanical and Production Engineering, Niigata University, Japan

Abstract University-industry research collaborations (UIRCs) have been recognized as an important factor of the production of innovation. In practice, however, the cases of the practical applications of UIRCs are not so many and there are a lot of problems in the UIRCs. In this paper, first the UIRCs conducted in Niigata University that is located in one of the regional areas are analyzed based on joint research projects and are clarified by company locations in order to clarify the characteristics of UIRCs in regional area of Japan. Moreover, the five cases of practical applications are extracted from the joint research projects with companies inside the prefecture and the cases of the practical applications are classified. These cases are discussed from the viewpoint of technologies and markets. Consequently, the product group and business direction for the analysis of the market was confirmed and was codified.

Keywords University-industry Research Collaboration, Joint Research Project, Practical Application, Innovation

1. Introduction

UIRCs have been recognized as an important factor for the creation of innovation. Further, the UIRCs have been encouraged in Japan from the view point of new industry and job creation [1]. Due to these encouragements of UIRCs, the number of joint research projects has increased about 1.8 times from 9,378 in 2004 fiscal year (fy) to 16,943 in 2014 fy in National Universities in Japan although the rate of the increase has been converged in recent years. The joint research projects in Japan are analyzed in the whole country [2].

Many results from UIRCs have been reported focusing on the sizes of the companies for collaboration partners [3-5], on the sources, characteristics, and financing, on the geographical distance between university and industry [6-8], and the consciousness for university researchers to university-industry collaborations [9]. Moreover, the effectiveness method and bout to advance university-industry collaborations have been reported [10-12], and conceptual model [13], model in open innovation [14] and limited model [15] of university-industry collaborations between small-medium companies and universities in regional area in Japan have been proposed. These results for collaboration depend on country, area, and industry etc.

Although the number of joint research projects has increased in Japan as mentioned above, in practice, the cases of the practical applications of UIRCs are not so many and there are a lot of problems. The main reason is as follows: The small-medium companies rather than large companies are accumulated in Japan. It is difficult to develop the UIRCs to practical applications for small-medium companies by themselves because the small-medium companies are lacking in funds, technologies, and organizations.

In the previous paper [16], the UIRCs were analyzed based on the case study of joint research projects in order to clarify the structure of the UIRCs in regional areas of Japan. Niigata University is (1) a medium scale university, (2) is located in regional area in Japan, (3) and has nine facilities including Facilities of Humanities, Education, Law Economics, Science, Medicine, Dentistry, Engineering and Agriculture. The graduate schools correspond to their facilities, respectively.

In this paper, first the UIRCs conducted in Niigata University that is located in one of the regional areas are analyzed based on joint research projects focusing on recent trends in order to clarify the characteristics of UIRCs in regional areas of Japan. Moreover, the five cases of practical applications are extracted from the joint research projects with companies inside the prefecture and the cases of the practical applications are classified. These cases are discussed from the viewpoint of technologies and markets. Consequently, the product group and business direction for the analysis of the market was confirmed and was codified.

2. Analysis of Joint Research Projects

The joint research project is essential for the UIRCs because the contract content including the ownership of the

intellectual property is clearly defined and private companies are the main partners. Therefore, the analysis of joint research projects becomes the first stage in order to understand the present situation of the UIRCs. In this section, the trends of joint research projects in National Universities in Japan by time series are shown and the characteristics of companies that engage in joint research projects in Niigata University are analyzed focusing on recent trends.

Figure 1 shows the numbers and budgets of joint research projects in National Universities in Japan by time series in the period from 2004 fy to 2014 fy [17]. The national universities have been turned into independent administrative entities in 2004 fy shown in Fig. 1. The numbers of joint research projects have been increasing steadily except that in 2009 fy. The reason of the decrease of the number in 2009 fy is the economic downturn precipitated by the Lehman Brothers bankruptcy in 2008. The budgets have been also increasing steadily except that in 2009 fy as well as the number.

On the other hand, 1,789 joint research projects have been conducted in Niigata University in the period from 2004 fy to 2014 fy. The average budget per project is about 1,226 thousand yen (about 11.6 thousand US dollar) and is not so high compared with others for the country.

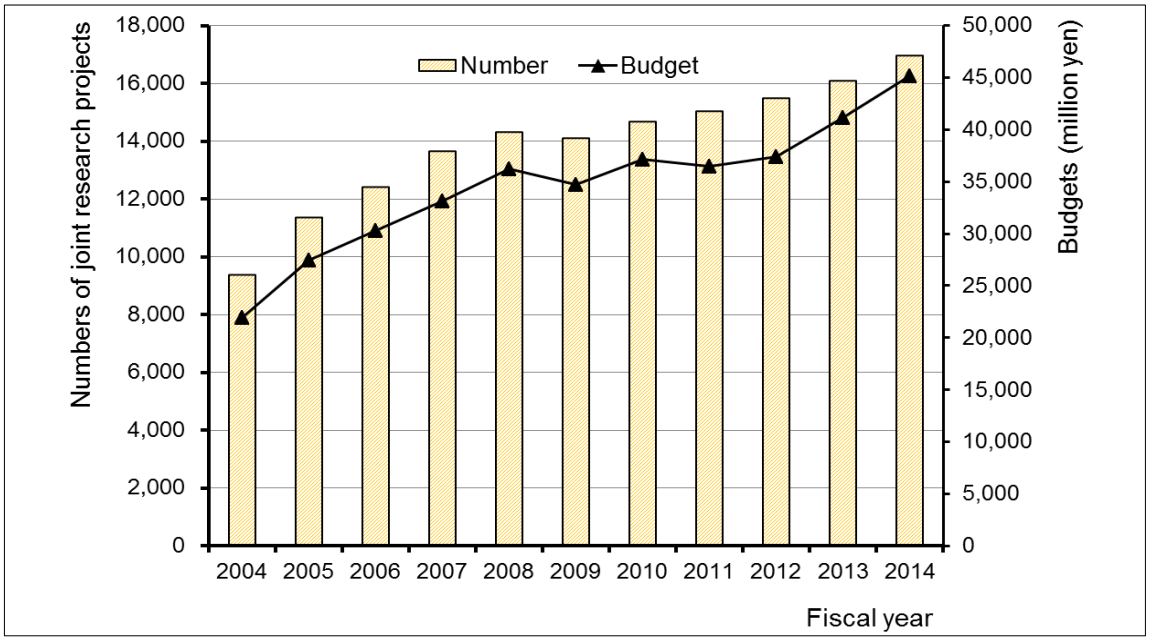


Figure 1. Numbers and budgets of joint research projects in National Universities in Japan by time series

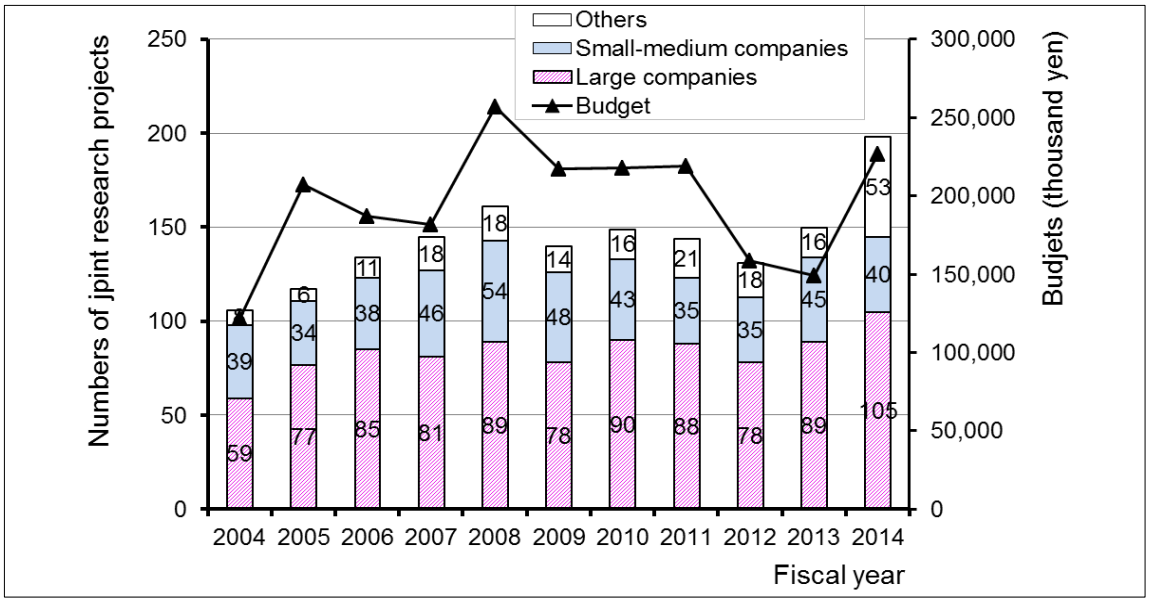


Figure 2. Numbers of joint research projects in Niigata University dividing collaboration partners into large, small-medium companies, and others by time series and their total budgets

Figure 2 shows the numbers of joint research projects in Niigata University dividing collaboration partners into large, small-medium companies, and others by time series in the period from 2004 fy to 2014 fy and also shows those total budgets at each fy. First, examining the trends regardless of the company scales, the number of joint research projects is 198 in 2014 fy and this is 1.9 times than 106 in 2004 fy. This increase is almost the same as 1.8 times in the whole country. Next, examining the trends of company scales, while the numbers of the large companies have shown increase slightly, the numbers of small-medium companies have almost remained flat. The reason is as follows: The various policies to encourage the UIRCs have been established in Japan. The small-medium companies inside the prefecture have maintained the status quo in the mind toward the policies while large companies have responded to the policies sensitively. The rate of the large companies is about 58 percent and it is higher relatively than that in the whole country. Therefore, the large companies have been the main partners in the limited area of Niigata Prefecture although the small-medium companies are more than 90 percent of the companies inside the prefecture.

Table 1. Classified areas and corresponding prefectures in Japan

Classified areas	Corresponding Prefectures
Hokkaido, Tohoku	Hokkaido, Aomori, Iwate, Miyagi, Akita, Yamagata, Fukushima
Kanto	Ibaraki, Tochigi, Gunma, Saitama, Chiba, Tokyo, Kanagawa
Koushin'etsu	Yamanashi, Nagano, (Niigata is classified independently)
Hokuriku	Toyama, Ishikawa, Fukui
Tokai	Gifu, Shizuoka, Aichi, Mie
Kinki	Shiga, Kyoto, Osaka, Hyogo, Nara, Wakayama
Chugoku	Tottori, Shimane, Okayama, Hiroshima, Yamaguchi
Shikoku	Tokushima, Kagawa, Ehime, Kochi
Kyushu, Okinawa	Fukuoka, Saga, Nagasaki, Kumamoto, Oita, Miyazaki, Kagoshima, Okinawa

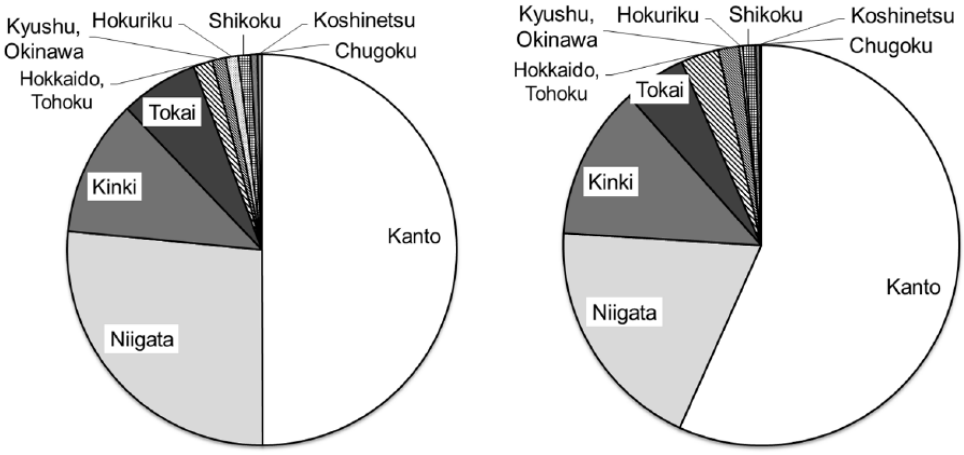
3. Classification of Joint Research Projects by Company Locations

The collaboration partners of the joint research projects conducted in the period from 2004 fy to 2014 fy in Niigata University were classified by company locations for collaboration partners in the country. As for Japan, we have 47 prefectures. In this paper, Japan was classified to nine areas as shown in Table 1 and Niigata prefecture located in Niigata University in order to clarify the location roughly. Further, the classifications are assumed as follows: Since private companies are the main partners for joint research projects, only private companies for collaboration partners are taken up. Although some joint research projects without budget exist, these projects are not included.

As the results arranged based on above assumptions, the numbers and budgets of joint research projects in the period from 2004 fy to 2014 fy in Niigata University were 1,069 and 1,634 million yen, respectively.

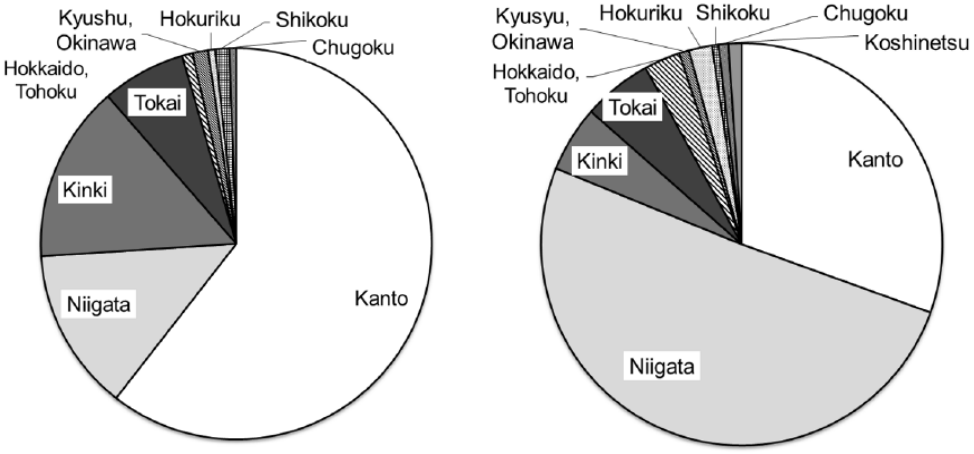
Figure 3 shows the rates of the numbers and budgets classified by the areas of company locations of joint research projects in Niigata University based on Table 1 in the country. The numbers of the joint research projects in decreasing order are Kanto, Niigata, Kinki, and Tokai areas as shown in Fig. 3 (a). The numbers in these areas account for 94 percent of the total. The numbers in the other areas account for less than 2 percent of the total, respectively. The numbers in Niigata prefecture located in Niigata University accounts for 27 percent of the total. The budgets of the joint research projects in decreasing order are Kanto, Niigata, Kinki, and Tokai areas as well as the number as shown in Fig. 3 (b). The budgets of the joint research projects in only Kanto and Kinki areas account for 69 percent of the total. The budgets in Niigata prefecture account for 19 percent of the total. Since the rate of the number in Niigata Prefecture is 27 percent as mentioned above, the joint research projects with relatively small budgets are conducted inside the prefecture.

Figure 4 shows the rates of the numbers classified by the areas of company locations of joint research projects, distinguishing large and small-medium companies. The numbers of the large companies in joint research projects in decreasing order are Kanto, Kinki, Niigata, and Tokai areas as shown in Fig. 4 (a). The numbers in these areas account for 96 percent of the total. The rate of the companies in Kanto area is the highest and is 61 percent. The numbers of the small-medium companies in joint research projects in decreasing order are Niigata, Kanto, Tokai, and Kinki areas as shown in Fig. 4 (b). The numbers in these areas account for 92 percent of the total. The rate of the companies in Niigata Prefecture is the highest and is 51 percent. Consequently, the collaboration partners are mostly in Kanto area for large companies and the collaboration partners are mostly in Niigata Prefecture for small-medium companies. This means that the large companies conduct joint research projects with a wide range of universities and small-medium companies conduct joint research projects with universities inside the prefecture.



(a) Numbers (1069) (b) Budgets (1634 million yen)

Figure 3. Rates of numbers and budgets classified by areas of company locations of joint research projects in Niigata University



(a) Large companies (692) (b) Small-medium companies (377)

Figure 4. Rates of numbers of large and small-medium companies classified by areas of company locations of joint research projects in Niigata University

4. Cases of Practical Application

The rate of joint research projects with private companies in Niigata Prefecture is 27 percent as mentioned above and is not so high. However, from the viewpoint of regional activation, it is important to create the joint research projects with companies inside the prefecture and to lead the joint research projects to practical applications. The process to lead the joint research projects to practical applications is not clear enough although it seems that the schemes to a joint research project are in various fields [15]. In this chapter, the practical applications are extracted from the joint research projects. In this case, the cases led to industrialization through the joint research projects with companies inside the prefecture are targeted. As a result, the five cases of practical applications are extracted.

4.1. Development of Equipment for Photosynthesis Advance in Oil Combustion System

The cultivations of strawberries in Niigata Prefecture do not grow up due to the low temperature and low amount solar radiation in winter. Therefore, the full-grown period becomes long and sugar content becomes high comparing with the cultivations in warm area. The “Echigo-hime” is a new type of strawberry in which the breeding is conducted so that fits to the climate in Niigata Prefecture. A company has developed the equipment for photosynthesis advance in oil combustion system. For this reason, the test of the growth improvement of “Echigo-hime” which was cultivated using this equipment was conducted in Niigata University. As a result, the increases of cumulative amount and sugar content, and the largeness of fruits were confirmed by the effectiveness of charity of carbon dioxide [18].

4.2. Development of Rice Powder Bread for Allergy Free

An egg, milk, and wheat are mainly taken up for three kinds of allergies. The adult patients are occupied and obstinate in the case of the food allergy of wheat. A natural ferment has been started to produce since Food Research

Center, Niigata Agricultural Research Institute, has processed bread to a rice powder in 2001. However, it becomes possible to produce the bread made of a rice powder when active gluten is added. The bread made of a rice powder in which the patient of a wheat allergy can eat in peace has been tried to produce. They have added hydroxypropyl methylcellulose and have established to produce the bread made of a rice powder without a wheat allergy due to the thought toward a good taste [19]. However, the mass production of the bread utilizing the existing equipment has been difficult since the specific equipment has been needed in the produce field of the bread. Due to the flood occurred in 2004, it has become impossible to utilize the existing equipment and half a year has continued not to produce the bread. On this occasion, they have started to introduce the new equipment and to produce the bread made of a rice powder.

4.3. Development of Tongue Brush for Mouth Care

The president in a company that has conducted horticultural industry has taken the scent of a cigarette to heart and has tried to use commercial tongue brushes. However, the president has considered that these tongue brushes have not fitted for the mouth care of the aged people of advanced years. Therefore, the president has started to develop a tongue brush for the mouth care of the aged people of advanced years. The width and thickness of the tongue brush are 31 mm and 13 mm, respectively, and the brush is made of a special nylon. The both sides of the brush are useful. The one side is flat for a tongue surface and the other side is a depressed form that can remove dirt. However, a bacterium in the mouth often causes the pneumonia of the aged people of advanced years. Therefore, he started to develop a tongue blush so that the hit is soft and dirt is removed. For this reason, the technical consultation has been conducted in Niigata University in order to confirm the validity of the effectiveness of the tongue brash for the occupant in the facility for the aged people of advanced years. The research collaboration in Niigata University has started and the validity of the effectiveness of the tongue brash has been confirmed [20].

4.4. Development of Measurement Equipment of Battery in Automobile

The loss inside the battery in automobile has increased when it has been used for a long time. In this case, it is difficult to take out the current and the automobile always stops. Therefore, it is necessary to measure the resistance inside the battery in automobile. However, the magnitude and direction of the current inside the battery in automobile change, at engine starting and usual drive moments, respectively. Therefore, the measurement equipment of battery in automobile has been developed. This equipment has the characteristic that can measure the resistance inside the battery in a run without the voltage outside. For this reason, the analysis of measured data and the method of data processing have been developed in Niigata University. As a result, the effectiveness of this equipment has been confirmed in automobile in a run [21].

Table 2. Classification of cases of practical applications by technologies and markets

		Technology		
		Existent		New
		Oneself	Outside	
Market	Existent			
	Periphery	(1) (2)	(4) (5)	
	New			(3)

4.5. Development of Quick Hydrogen Gas Sensor

The gas sensor has been needed in a company. A coordinator has found the knowledge which is behaviors of the hydrogen in metal in Niigata University. The related three organizations have made a license contract and the product has been developed. The product is a quick hydrogen gas sensor and it can detect hydrogen gas in a moment utilizing an electromotive force. This sensor has high performance comparing with the conventional products in a detection speed, tip capability, selection, life, and production cost. This case has been valued highly for the promotion of the UIRCs concerning the technology transfer in a university in a regional area [22]. Hereafter, a contribution of the sensor to a market is promising since it is assumed that the demand of a hydrogen fuel cell increases.

5. Classification of Cases of Practical Application

In this chapter, the cases of sections 4.1-4.5 are replaced by (1)-(5), respectively.

The practical applications extracted from the joint research projects are regarded as “New business” and are classified from the viewpoint of technologies and markets. The technologies are classified into the following three parts. (I) The existent technology becomes deep and otherwise it is applied and is expanded. This is regarded as “Oneself”. (II) The outside existent technology is applied and is expanded although the company does not have the direct technology. This is regarded as “Outside”. (III) The technology is newly developed in the company. This is regarded as “New”. On the other hand, the markets are classified into the following three parts. (I) The new product is provided to the present business field. This is regarded as “Existent”. (II) The new business is developed on the surrounding the relating technology. This is regarded as “Periphery”. (III) The new technology is developed in the different field. This is regarded as “New”. The cases (1)-(5) are expressed as matrix relations of the technologies and markets as shown in Table 2.

In the case (1), the equipment for photosynthesis advance in oil combustion system gas has been expanded from the existing kerosene fan heater by oneself. Therefore, the case (1) corresponds to "Existent" and "Oneself" from the viewpoint of technology. The equipment for photosynthesis advance in oil combustion system gas has targeted the surrounding the kerosene fan heater by oneself on the markets. Therefore, the case (1) corresponds to the "Periphery" from the viewpoint of market. In the case (2), the rice powder bread for allergy free has been expanded from existing bread by oneself. Therefore, the case (2) corresponds to "Existent" and "Oneself" from the viewpoint of technology. The bread has targeted surrounding the bread by oneself on the markets. Therefore, the case (2) also corresponds to the "Periphery" from the viewpoint of market. In the case (3), the tongue brush is different from original business on both technology and market because the company that has developed the tongue brush had conducted horticultural industry originally. Therefore, the case (3) corresponds to "New" from the viewpoint of both technology and market. In the case (4), the measurement equipment of battery in automobile has been developed from the existing resistor by oneself with another company. Therefore, the case (4) corresponds to "Existent" and "Outside" from the viewpoint of technology. The measurement equipment has targeted the surrounding the resistor on the markets. Therefore, the case (4) corresponds to the "Periphery" from the viewpoint of market. In the case (5), the quick hydrogen gas sensor has been developed with another company based on the seeds in Niigata University. Therefore, the case (5) corresponds to "Existent" and "Outside" from the viewpoint of technology. The gas sensor has targeted the surrounding the existing medical and beauty equipments by oneself on the markets. Therefore, the case (5) corresponds to the "Periphery" from the viewpoint of market.

Only case (3) applies to "New" in both technologies and markets. The cases (1) and (2) apply to "Oneself" on the technologies and apply to "Periphery" on the markets. The cases (4) and (5) apply to "Outside" on the technologies and apply to "Periphery" on the markets, too. This means that almost UIRCs apply to "Oneself" or "Outside" on the technologies and apply to "Periphery" on the markets.

Table 2 can be compared with the product-market matrix that has been proposed by Anssof when the technology is regarded as "Product" which is embodied in research and development [23]. This product-market matrix has been proposed in order to confirm the product group and business direction for the analysis of the market.

The inventions have been created in joint research projects (2), (3), (4), and (5) and have been registered as joint patents between the university and industry in (2) and (4), respectively. Therefore, the inventions play an important role depending on the field in order to lead to commercialization.

6. Conclusions

The main conclusions obtained in this study are summarized as follows:

(1) The UIRCs conducted in Niigata University that was located in one of the regional areas were analyzed based on joint research projects focusing on the recent trends in order to clarify the characteristics and problems of UIRCs in regional areas of Japan.

(2) The joint research projects were classified by company locations for collaboration partners and the characteristics were clarified.

(3) The cases of practical applications were extracted from the joint research projects conducted inside the prefecture.

(4) The extracted 5 cases were classified to the extent (oneself and outside) and new in technologies, and to the existent, periphery, and new in market, respectively.

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