

Exploring a Conceptual Framework for Academic Entrepreneurship: Beyond Pasteur's Quadrant

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Abstract

Noting that one of the new roles of universities is the commercialization of knowledge, this paper searches for a conceptual framework for analyzing scientists who have committed themselves to activities related to that new role. The author considered one of the frameworks utilized up to now in research—Pasteur's Quadrant—and found two points as follows; first, the framework of Pasteur's Quadrant can be applied as is to analyzing scientists who have committed themselves solely to collaboration between academia and industry. Second, Pasteur's Quadrant needed several adjustments for applying it to founders of university spin-offs. The most important adjustment was adding an index called "entrepreneurial propensity."

Keywords: commercialization of knowledge, university spin-offs, entrepreneurial propensity

1. Introduction

The Bayh-Dole Act (U.S. Law 96-517, Patent and Trademark Act Amendments of 1980) added a new role to universities. Ever since the system of universities developed in medieval Europe, the two main roles of universities were widely recognized to be "To codify knowledge" and "To teach the codified knowledge." Universities over the years faithfully performed those two roles.

After the Second World War, however, and especially in the post-Bayh-Dole era, society, particularly industry and the government came to expect universities to play a new role by creating knowledge that gave birth to economic value and transferring it to industry. This new role is frequently called "the commercialization of knowledge."

In this way, besides the traditional roles of codifying and teaching knowledge, the commercialization of knowledge has today become a third role of universities. The most famous successful example of knowledge created at a university and then being commercialized, giving birth to profits, and having a strong impact on society and people, is the Cohen-Boyer patent of Stanford University. Stanford University is a main player whose

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name frequently appears in the impressive success stories of companies located in California's Silicon Valley, and is one of the universities that has continually carried out the new university role of commercializing knowledge. Many other universities around the world have also successfully showed steady results in commercializing knowledge, including MIT, University of California at San Francisco, Carnegie-Mellon University, University of Texas, Cambridge University, Oxford University, and Beijing University. Universities in Japan aggressively tackling the commercialization of knowledge include the University of Tokyo, the Tokyo Institute of Technology, Tohoku University, Osaka University, and Yamagata University.

Although these universities, all of which gladly take on the new role of commercializing knowledge, still do not comprise the majority of universities in number, they are mostly prestigious universities boasting of long traditions. A primary example of commercialized knowledge by a prestigious school is the Cohen-Boyer patent of Stanford. That success resulted in gaining the attention of society and strengthening the expectations toward universities as sources of knowledge that leads to innovation.

Ironically, however, the stronger the expectations grew, the bigger the concern of corporations and government became, since the knowledge in university rarely came to be tied directly to business or innovations. Although government and industry provide substantial financial support to universities for funding research, there are only few instances in universities where knowledge gave birth to economic value. Most research results—even if they had important scholarly value—were not the breakthrough technology industry hoped for.

Alternatively, even if a university developed breakthrough technology, it was either not possible to transfer it readily to industry, or else the small amount transferred did not lead to economic value. In short, it did not bear fruit in the form of innovations.

Innumerable obstacles (Carlsson called them “filters”) exist in the process of knowledge transfer from university labs to business. Only rarely does knowledge developed in a university succeed in clearing all obstacles and result in earning large profits in biotechnology, semiconductors, materials, and other industrial fields. Even when knowledge transfer is occurring, behind every success story are dozens, even hundreds, of stories of failure.

In those circumstances, innovation researchers began asking the question: “Why doesn't new knowledge always result in (new) economic activity?” (Carlsson, et al., 2009). They conducted surveys to find the answer by closely examining the entire mechanism for commercializing knowledge. They investigate the process by which new knowledge is created in labs, followed the steps university scientists took in reporting their research results to Technology Licensing Offices (TLO), observed the patenting activities of TLOs, and paid

attention to how the scientists transferred the new knowledge to the industrial sector to create economic value.

Based on those many surveys, the characteristics of scientists who succeeded in commercializing knowledge have today gradually become clear. Although the details of the analyses differ depending on the particular research paper, it became clear that compared to other scientists, almost all the scientists classified in *Pasteur's Quadrant* (Stokes, 1997) skillfully managed the knowledge commercialization process.

One result is that research related to so-called "Pasteur scientists" (Baba, et al., 2009) is flourishing in today's innovation study principally because those scientists are supposed to provide the university knowledge that eventually becomes the breakthrough technology corporations seek.

Although research related to Pasteur scientists examines activities tied to the commercialization of knowledge, the focus is often placed on university-industry (U-I) collaboration, paying particular attention to the phenomenon where the transfer of knowledge between university scientists and corporate researchers is occurring in either one-way or two-way. An analysis is conducted to determine the conditions to be satisfied for knowledge transfer to be effective and efficient.

As research intensifies and research themes expand, enhanced attention is now being paid not only to U-I collaboration but also to the firm creation by university scientists as a new type of activity for commercializing knowledge.

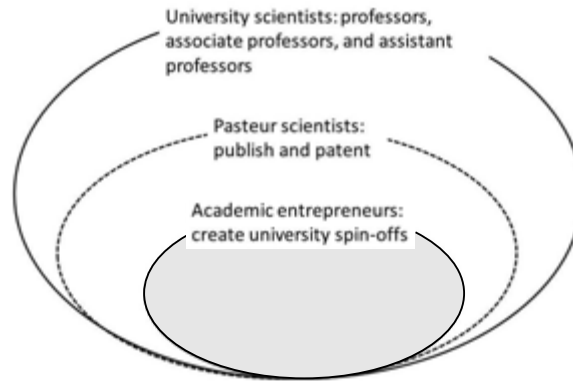
As related above, however, research into the creation of university spin-off firms by university scientists is derived from an analysis of Pasteur scientists and the U-I collaboration they conduct. As a result, therefore, the research framework used is the same as that used for analyzing Pasteur scientists. In short, it is based on the premise that included among university scientists are some Pasteur scientists, and among them are those who create university spin-off firms. The latter scientists were thus classified without detailed discussion (see Fig. 1).

The author, however, believes there are serious problems with that analytical method. In order to isolate the characteristics of the university scientists who create university spin-offs, major adjustments must be made to the existing analytical framework while referring to the accumulated knowledge in the area of business entrepreneurship.

This paper points out the limitations of the framework of Pasteur scientists, and suggests a more adequate framework for analyzing university scientists who create university spin-offs. In the process, the author shed light on a previous research that emphasizes "entrepreneurial propensity."

This paper is comprised of five parts: Part 1 is this Introduction; Part 2 discusses the traditional roles that universities should play and their new role; Part 3 discusses how

Fig. 1. University scientists, Pasteur scientists, and academic entrepreneurs



Pasteur’s Quadrant has become a set of stylized facts for innovation researchers, and examines the effectiveness and limitations of Pasteur’s Quadrant as an analytical framework; Part 4 discusses the analytical framework needed when studying academic entrepreneurship; and Part 5 provides tentative conclusions as of the moment.

2. The traditional role versus the new role of academics

It is widely believed that universities developed from monastery and cathedral schools in medieval Europe. Università di Bologna (established around 1088), Université de Paris (established around 1160), and The University of Oxford (established around 1190) are among the oldest universities. During the middle ages, the role of universities was to investigate and collect evidence of “the workings of God” and to codify and teach them. Over the centuries since then—through the Renaissance Period, the Modern Age, and the Contemporary Age—changes occurred. University research moved away from “the workings of God” to “general knowledge,” however, the roles of universities remained unchanged as “codification” and “teaching.”

Much time passed again, and various technologies were utilized during the Second World War, and many university scientists participated in projects such as the successful Manhattan Project. That experience caused many people to believe that in the period since the end of the Second World War, academic research is immediately utilized and commercialized. Most academic research, however, remained basic and had no immediate impact on the business sector nor did it create economic value. As well, the basic roles of universities remained as they were in the Middle Ages in Europe: “to codify knowledge” and “to teach the codified knowledge.”

The turning point for substantially changing university traditions is said to have been the

1980s. Around that time, especially in the United States, there was a dynamic shift toward stronger intellectual property rights, a new value system. It spread not only among corporations but widely throughout society, including governments and individuals. Universities were no exception. The purpose of the Bayh-Dole Act that the U.S. Congress passed in 1980 was “to facilitate commercialization of the results of federally funded research by transferring the intellectual property rights from the funding agencies to the universities in which the research was carried out.” (Carlsson et al. 2009, p. 1220).

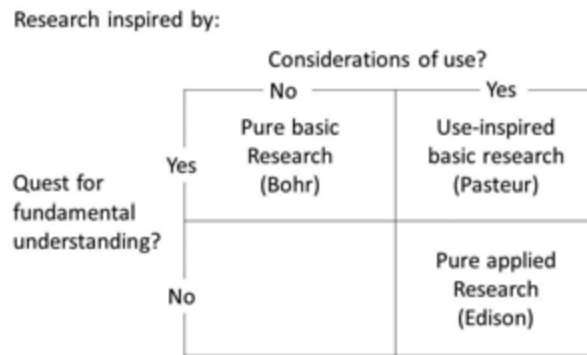
After 1980, a business model emerged in which knowledge developed in universities was patented through TLOs and transferred to private companies. Utilizing the patents, the companies developed breakthrough technology, provided new products and services to the market and society, and earned profits. At the same time, universities and university scientists, in addition to traditional “codification” and “teaching,” provided knowledge and patents that met social demands and afforded benefits to companies and society while earning profits themselves. That was a new role for them—the role of commercializing knowledge—and it was recognized that they were performing that new role.

3. Analytical framework for university scientists

3.1 “Pasteur’s Quadrant” of Donald Stokes

As the new role of universities became recognized and the number of university scientists increased who vigorously accepted that role, centered on those in the U.S., Professor Donald E. Stokes of Princeton University published *Pasteur’s Quadrant: Basic Science and Technological Innovation* in 1997. Stokes shed light on the inspiration that leads scientists to devote themselves to research activities (Fig. 2). The Pasteur’s Quadrant model he articulated argued that scientists in basic research could be categorized following a dual dichotomy, which he exhibited as a fourfold table with cells or quadrants. He called three of the quadrants “Bohr’s quadrant” (pure basic research), “Edison’s quadrant” (pure applied research), and “Pasteur’s quadrant” (“use-inspired basic science”). He did not name the remaining quadrant because it did not exist in the real world. Pasteur’s quadrant, the quadrant that university scientists who are involved in the new role fit into, gained particular attention. The reason is the expectations held toward those scientists for performing effectively and efficiently both the traditional roles of universities and the new role (Baba et al., 2009).

What method is actually used, then, to identify university scientists who fit in the Pasteur’s quadrant? Up until now, almost all research into this question divided scientists into two types: those included in Pasteur’s quadrant and those not, referring to data such as papers the scientists authored and their patenting activities (Gittelman and Kogut, 2003 ; Meyer, 2006; Baba et al., 2009). Gittelman and Kogut, for example, closely reviewed papers and patents and called those who conducted research and patenting “bridging scientists” for the way they

Fig. 2. Stokes's quadrant model of scientific research

source: Stokes (1997), p. 73

tied university knowledge to the needs of industry. Baba et al., meanwhile, paid close attention to the number of patents applied for and the quality of publications, and called those who performed at a high level in both areas “Pasteur scientists.”

In this way, reviewing papers and patents became the standard research method for identifying Pasteur scientists. Today, this same method is used frequently to identify academic entrepreneurs.

3.2 Limitations of Pasteur's Quadrant

The academic entrepreneurs discussed in this paper are often positioned in traditional research as being included among Pasteur scientists (Buenstorf, 2009).

The results of an analysis by Fini et al. (2010), however, that covered 11,572 university professors, reported that “a large share of academic entrepreneurship occurs outside the IP system” of universities (Fini et al., 2010, p. 1060). In other words, the analysis said that whether individual academic scientists create spin-off firms is unrelated to whether they own patents. If that report accurately reflects the real world, it is possible that academic entrepreneurs are not included among Pasteur scientists but belong to a different category of researchers. It can thus be hypothesized that the personal characteristics of academic entrepreneurs may differ from those of Pasteur scientists.

Meanwhile, Rejean et al. (2006) examined faculty members from a wide variety of research fields and universities of different status in Canada, and found that publishing and patenting are not important factors affecting the likelihood of firm creation. Rather, the important factors are the resources of universities to which the founder of university spin-offs attached.

Bercovitz and Feldman (2007) also found that factors other than publishing and patenting have a strong influence on the commercialization of university knowledge. In the results of

their analysis of faculty members in the medical departments of Duke University and John Hopkins University, they reported that scientists whose personal characteristics include both “inventive capacity” and “entrepreneurial propensity” have high potential for commercializing university knowledge. Entrepreneurial propensity is measured using data other than publishing or patenting, such as whether a scientist has immigration experience.

None of the foregoing analyses directly raises objections to the traditional research method of closely attending to publishing and patenting. They do point out, however, that when university scientists commit themselves to commercializing knowledge, there are other factors besides publishing and patenting (such as entrepreneurship and resources) that exert a strong influence on them.

3.3 Characteristics of Pasteur scientists that do not fit into Pasteur's Quadrant

In the previous section, the author explained, while quoting from published research, that factors other than publishing and patenting exist that heighten the likelihood of university start-ups. What exactly are those other factors? In preparation for considering the answer to that question, let us first clarify what kind of functions do university scientists fulfill in the process of commercializing knowledge.

As mentioned, most research to date defines Pasteur scientists as experts positively inclined toward conducting both patenting activities and basic research in order to extend the scientific frontier, and that research paid close attention to their publishing and patenting activities. That approach is based on the traditional production function of economics. The way of thinking used, in other words, is that if high-quality factors of production are invested, productivity increases. Pasteur scientists, who publish many papers and enthusiastically conduct patenting activities, are high-quality factors of production. The greater the number of Pasteur scientists, therefore, the higher the productivity of knowledge.

This way of thinking is a rational argument that follows the tradition of economics since Becker introduced the human capital theory. It has also been pointed out, however, that the function of university scientists is more than just that.

3.3.1 Legitimizing function of scientists

Luo et al. (2009) point out that scientists have two functions in the knowledge-intensive sector. The first is a “productive function.” Their embedded knowledge and human networks are factors of production. Luo et al. say the greater the volume of their knowledge and human networking, the more effective the commercialization of that knowledge can be. That way of thinking concerning Pasteur scientists is the same as seen in much other research already published.

We may find the uniqueness of the research of Luo et al. in the second function, the

“legitimizing function,” especially the assertion that scientists play a signaling role. They hold a discussion like this: for corporate managers, most of the advanced research fields in which academic scientists are involved contain much uncertainty. No one knows whether research in such fields will continually develop. It is also unclear whether the results of research will meet market needs.

Under these circumstances corporate managers will seek alliances with other players to reduce the risk. It is also difficult, however, for them to decide with which players to form an alliance. Since the course of development of the knowledge is unclear, corporate managers cannot predict what resources they will need. Not knowing that, managers cannot understand which player is the most appropriate to form an alliance with, in terms of the resources that player has.

If we hypothesize that academic scientists possess more robust advanced knowledge than corporate managers, then the words of Isaac Newton—“Standing on the shoulders of giants”—can be used, meaning that academic scientists may be able to see further ahead than managers. If that were true, it would benefit corporate managers to have information about how many scientists with what background are being committed to a particular research project. If they know that many university scientists being committed to a project also participated in previous successful projects, then managers can expect that the new project will also result in effective knowledge that meets market needs. Therefore, managers can choose a player as an alliance partner that has many scientists who have previously completed successful projects.

Worded differently, when corporate managers see that the future of a project that just got off the ground is uncertain, academic scientists can serve as guideposts for them.

After surveying over 300 U.S. companies in the biotechnology field, Luo et al. pointed out that “scientists serve more than just a research function in knowledge-intensive industries,” and explained how they have an additional function called a legitimizing function. When research has just begun and the related industry is still immature, the importance of the legitimizing function increases and academic scientists become guideposts.

In that backdrop, what data did Luo et al. use to measure the legitimizing function of academic scientists? It appears that they used publishing and patenting data to clarify both the productive and legitimizing functions. That means they analyzed only scientists belonging to Pasteur’s quadrant. In turn, that means scientists who have published extensively and have many patents are highly productive and can serve as guideposts for corporate managers wishing to avoid risk.

Do real-world managers, however, view all scientists with outstanding publishing and patenting performances as guideposts for avoiding risk? In commonsense view, scientists with many publications and patents, and who have particularly noteworthy characteristics,

may effectively work as guideposts for avoiding risk.

The author of this paper proposes it is more rational to say that not all scientists classified in Pasteur's quadrant have a legitimating function, but that some of them, along with some other types of scientists, do have that function.

3.3.2 Entrepreneurial propensity of scientists

In the previous section, the author introduced the legitimating function of scientists while quoting from the research of Luo et al (2009). The author also pointed out how that research attended only to scientists classified in Pasteur's quadrant. It seems, however, that the legitimating function pointed out in that research has a much wider application.

Bercovitz and Feldman (2007) surveyed a group of university scientists who actually commercialized knowledge in the biotechnology field, and pointed out that they had two unique characteristics: an "inventive capacity" and an "entrepreneurial propensity". As indicators for the former characteristic, Bercovitz and Feldman used publishing, patenting, and boundary-spanning-ness. For the latter, they used training experience in universities where the commercialization of knowledge was vigorous, and immigration experience.

Why, one might ask, is immigration experience necessary for commercializing knowledge? To answer that question, we must first explain the meaning of "entrepreneurial propensity." According to Bercovitz and Feldman entrepreneurial propensity is comprised of an ability to accept risk and a desire for control. In comparison to the traditional roles of codifying and teaching knowledge, the commercialization of knowledge is a substantially riskier undertaking. There is only a slight possibility that the results of university research will satisfy the needs of the industrial sector. In addition, even if they do satisfy those needs, there is additional difficulty in transferring that knowledge.

Even if those difficulties are overcome and knowledge is successfully transferred, moreover, it is still quite unclear that the market will evaluate any resultant product positively and that it will lead to profits. In addition, the determining factor for deciding the success or failure of commercializing knowledge is the "market," something unfamiliar to scientists.

In academia, the world that university scientists are accustomed to, peers evaluate the results of research. Markets, however, evaluate the results of activities related to commercializing knowledge. Persons who dare to step outside the world they are accustomed to and be evaluated in a different world should have a higher ability than others toward risk-taking. In short, such persons are rich in entrepreneurship.

In addition, through direct interviews, Bercovitz and Feldman (2007) discovered that university scientists who dare to be evaluated in a different world—in a market—have a strong desire to commercialize products derived from the results of their own research and to introduce the products into a market themselves.

The strength of a scientist's "risk-taking ability" and "desire for control," meanwhile, is impossible to measure. Bercovitz and Feldman thus looked elsewhere for data it was possible to collect and reveal those two characteristics. After careful consideration, they realized they could use immigration experience for that purpose. They thought that persons who leave their native country to work in another country of which they know nothing about have a high risk-taking ability and, in wishing to live as they want, they also have a strong desire for control. Scientists with immigration experience, therefore, have a strong risk-taking ability and desire for control, two indicators for a rich entrepreneurial propensity. Bercovitz and Feldman maintain that a rich entrepreneurial propensity matches the characteristic of scientists enthusiastic toward commercializing knowledge.

Earlier, when discussing the legitimating function of Luo et al., this paper broached the question of whether that particular characteristic held by some Pasteur's scientists might be shared commonly with special kind of researchers in a separate category. The entrepreneurial propensity of Bercovitz and Feldman discussed in this section might be one of those characteristics. In other words, some scientists enthusiastic toward commercializing knowledge have a high entrepreneurial propensity. Corporate managers view persons with a high entrepreneurial propensity as dependable individuals with noteworthy characteristics. The author of this paper surmises that managers in industrial sector will view such persons as guideposts for avoiding risk.

3.3.3 Motives and incentives for commercialization

Up to now in this paper, the author has discussed the legitimating function pointed out by Luo et al (2009) and argued that it is not a function held by all scientists included in Pasteur's quadrant but a separate noteworthy characteristic held by only a fraction of Pasteur's scientists. The author also said it is possible that the separate noteworthy characteristic might very well be the entrepreneurial propensity presented by Bercovitz and Feldman (2007).

Bercovitz and Feldman used the presence or absence of immigration experience for measuring entrepreneurial propensity. Here, however, the author introduces other promising data for measuring entrepreneurial propensity.

As mentioned, university scientists who commit themselves to commercializing knowledge conduct highly risky activities. In order to explain why some scientists dare to undertake highly risky activities, Bercovitz and Feldman said it was because they had the individual characteristics of a capacity for high risk-taking and a strong desire for control. They also said that scientists who have these two characteristics are quite likely to be involved in highly risky behavior such as immigration, and they choose to commit themselves to commercializing knowledge. In other words, aspects of their very nature influence their decision about whether or not to take risky behavior like firm creation.

The method of attending closely to innate personal characteristics when analyzing entrepreneurial propensity is supported by other research as well, and the author of this paper agrees with that method. At the same time, however, acquired characteristics should also be considered. Examples of acquired characteristics include previous experience of collaborative research (D'Este and Patel, 2007), the presence of an entrepreneurial climate (Gilsing et al., 2010), and others. Here, this author introduces two representative acquired characteristics: financial incentives and motives.

Sauerman et al. (2010) surveyed 2,000 U.S. university scientists to determine what effect financial incentives and motives had on their research and their commitment toward activities for commercializing knowledge. "Financial incentives" here refer to the share of licensing income going to the inventor. "Motives," meanwhile, refer to the preference of individual scientists regarding compensation. Specifically, the respondents were asked to choose from among "money," "intellectual challenge," "advancement," and "contribution to society" as the most important factor when beginning a research project. A numerical value was given according to their choice.

An analysis of the survey's results showed that financial incentives had no strong influence on the scientists. Motives, in sharp contrast, clearly showed a strong influence on commitment toward commercializing activities. It was also pointed out that the content of motives differed according to field of study. In particular, while pecuniary motives were strong predictors of commercialization among scientists in the physical sciences, the desire to contribute to society was the most important motive among those in the life sciences.

Sauerman et al., using data from U.S. researchers, showed clearly that motive rather than financial incentives was the key factor in commercializing knowledge. The same conclusion was reached in other survey of U.S. scientists (Colyvas et al., 2002), as well as European scientists (Murray, 2006; Krabel et al., 2010; Haeussler and Colyvas, 2009).

When measuring entrepreneurial propensity, innate individual characteristics—such as risk-taking capability and desire to control—and acquired characteristics should both be included as a variable of analysis.

4. Conceptual framework for academic entrepreneurship

Up to now, this paper introduced the analysis framework of Pasteur's Quadrant and discussed its limitations. Pasteur's Quadrant, which emphasizes publishing and patenting, is an appropriate framework for analyzing the productive function of university scientists who commit themselves to the commercialization of knowledge. It has the shortcoming, however, of not being able to explain well the legitimating function. To overcome this shortcoming, it is necessary to add entrepreneurial propensity as a variable of analysis. When measuring entrepreneurial propensity, however, data outside Pasteur's Quadrant, such as risk-taking

ability, desire to control, and motives are necessary.

This section considers in greater detail what is needed to measure entrepreneurial propensity, based on the discussion up to now.

4.1 Units of analysis

Up to now, without any in-depth discussion, the unit of analysis was considered to be the individual university scientist. Earlier research, however, used both macro units of analysis such as the university, and micro units of analysis such as individual scientists. Research using macro units mainly analyzed the effect of university policy on the commercialization of knowledge. Representative research in that area is by Roberts and Malone (1996), DiGregorio and Shane (2003), and O'Shea et al. (2005).

Research using micro units mainly analyzed the individual characteristics of researchers committed to commercializing knowledge. Those characteristics included publishing and patenting, of course, as well as the characteristics of the universities they were attached to, their positions in the universities, their educational experience, age, the size of the funds they obtained for research, their human networks, alma mater, professional background, mobility, immigration experience, and so forth.

Since the researches from a macro point of view use universities as the unit of analysis, they can acquire accurate data relatively easily. Precise and comprehensive research results can thus be expected. In contrast, research from a micro point of view use individual scientists as the unit of analysis, so they must identify individual scientists committed to commercializing knowledge. In order to complete that identification, they have to prepare their own datasets based on existing databases with limited volumes of information such as that related to publishing, patenting, and funds granted for research. In the course of those preparations, problems emerge such as researchers having the same family name and first name (Meyer, 2006), thus seriously harming the accuracy of the research. In addition, a questionnaire survey is sometimes necessary. In other words, in comparison to research from a macro point of view, the efficiency of research that uses individual scientists as the unit of analysis worsens, and the scope of application for the analysis results is often limited.

Despite the drawbacks, much of recent research uses individual scientists as the units of analysis. The main reason is that such research clarifies a scientist's professional background and actual research performance, and especially the type of scientists who commit themselves to university spin-offs. Worded differently, such research allows an analysis of the impact and skills of the founders of university spin-offs (Rejean et al., 2006).

Another reason is that the research provides a clue for answering the question of whether an individual scientist is able to perform all the traditional and new roles of a university. This is an important point when considering national systems of innovation and the actual

functions of universities within the system. Pioneering knowledge is among the seeds of innovation, and innovation provides the motive power for economic growth. Universities have been the source of such pioneering knowledge, and are expected to continue to be so in the future. The question has frequently been asked; however, of whether adding the new role of commercialization has negatively affected the value of universities as sources of pioneering knowledge. This issue has been called a "trade-off" for publishing and patenting. It is concerned that whether scientists, committed to commercialization activities and who thus spend much time on patenting, pay a price of having less time and resources available for publishing (in short, for producing pioneering knowledge).

Various analyses are being conducted at present related to this question, often concluding that the trade-off problem does not exist. As yet, however, the analyses have not produced stylized facts, and it remains an area where more research is required. Making individual scientists the units of analysis is an appropriate method for clarifying this issue.

The third reason for using individual scientists as the units of analysis is the need, when studying a scientist's commercialization activities—especially founders of university spin-offs—to apply research accumulated in the area of entrepreneurship theory, a quite different field. Much research has been published concerning the correlation between the personal characteristics of entrepreneurs and the likelihood of firm creation in the circumstances surrounding them, and that research used individuals as the units of analysis.

In the context of the foregoing reasons, it is most appropriate to use individuals as the units of analysis when studying university scientists committed to commercializing knowledge, especially founders of university spin-offs.

4.2 Samples

According to Rejean et al. (2006), most of the existing research in the U.S. and Europe uses as samples university scientists attached to elite research universities. From a resource-based view, Rejean et al. say that "like entrepreneurs in private firms, researchers are entrepreneurs who use a great number of idiosyncratic resources and capabilities." In order to clarify the overall picture of idiosyncratic resources and capabilities, therefore, they added scientists from non-elite universities to the samples. Specifically, they collected data related to all researchers who obtained research grants from Canadian government sources and used it as samples.

The author of this paper supports the research methods of Rejean et al. Not only researchers in the University of Tokyo and Osaka University, two elite universities enthusiastic about commercializing university knowledge, but all researchers who obtained grants-in-aid for scientific research (Kakenhi) from the Japanese government should be included as samples. In Japan, however, scientific research grants-in-aid tend to be

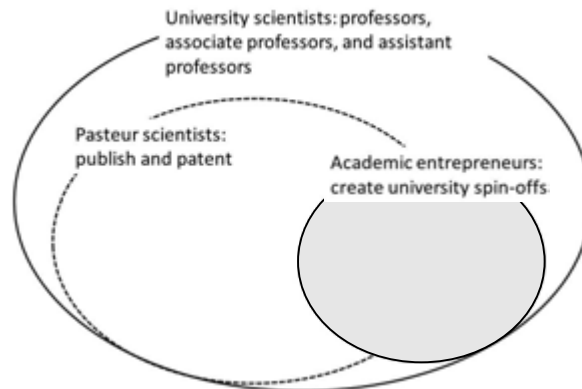
concentrated on a small number of elite universities. To overcome this problem, it is necessary to include samples other than those receiving such grants.

4.3 Conceptual framework

As a way to explain why some university scientists are more likely to create university spin-offs than others, this paper first reviewed the analytical framework of Stokes, called “Pasteur’s Quadrant,” to assess whether it adequately depicts the individual characteristics of each scientist. In that process, we pointed out that although scientists in the Pasteur’s Quadrant category possess a superior productive function, it cannot be said definitely that all of them possess a superior legitimating function.

What is the difference, then, between scientists who possess a legitimating function and other Pasteur scientists? What is it that comprises their legitimating function? A careful review of existing related research indicates entrepreneurial propensity seems to be an important factor. Entrepreneurial propensity, however, cannot be measured directly. Other indicators are needed, therefore, to reveal that propensity. The author of this paper did not identify all such indicators, but believes at the present moment that a strong risk-taking ability and a strong desire to control, both indicated by the presence or absence of immigration experience and motives, are strong contenders. Fig. 3 puts those factors in order.

Fig. 3. University scientists, Pasteur scientists, and academic entrepreneurs – conceptual framework revisited



5. Tentative conclusion

This paper throws a spotlight on the commercialization of knowledge, a new role of universities, and discusses what might be the most appropriate units of analysis, samples, and conceptual framework for identifying university scientists committed to commercialization, especially those who found university spin-offs. The Pasteur’s Quadrant framework

frequently used in past research might be most appropriate for analyzing researchers conducting activities related to commercialization, especially those committed to U-I collaboration.

For identifying with high precision the persons involved in firm creation, a much riskier activity, it is necessary to devise a new framework based on the Pasteur's Quadrant approach, by adding a new factor. In particular, it is essential to add a factor called entrepreneurial propensity. But what indicator can be used to reveal entrepreneurial propensity, and what data can be used for properly measuring it? For that purpose, research results from a different field, called entrepreneurial theory, must be referred to. That is an area of research the author hopes to study more deeply in the future.

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