From Technology to Product: A Case Analysis of the Commercialization Process of "Hydrotect" in TOTO

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Abstract

Creating technological knowledge and turning it into real products effectively are both the most significant strategic issues for all technology-oriented companies. It is not always the case, however, that companies good at knowledge creation are also good at its commercialization. As is often pointed out, much of the technological knowledge that companies have created is dormant being unutilized. The purpose of this paper is to explore a perspective on the management of technology commercialization process, based upon a case analysis of the commercialization process of "Hydrotect" in TOTO Ltd.

Hydrotect, a technology with anti-fogging and self-cleaning properties, was invented in 1995 and has brought the company more than JPY 20 billion in sales in these four years. In the fiscal 1999, the Hydrotect businesses have accounted for as much as 5 % of the company's whole sales. Observing carefully the commercialization process of the technology, we can see an interesting approach for technology commercialization: that is, the company let the technology exposed to others at the very early stage after the invention, through which it tried to understand the potential of the technology and appropriate directions of commercialization.

New technologies at the initial stage often perform far worse along some important technological dimensions compared with the relevant existing technologies, even though they could outperform later. They are also highly uncertain if they could bear any fruits at all and where it could do the most. For firms, it is totally hard to evaluate the true potential and opportunity of new technologies, and therefore they can not justify at once the investment on technology commercialization.

In such a situation, firms are supposed to take two different approaches: one is to enhance potential and opportunity evaluation capabilities concerning new technologies, and another is to reduce the uncertainty of the technologies itself. Enhancing potential/opportunity evaluation capabilities helps firms to detect analytically the value of the technologies and the directions of commercialization. On the other hand, reducing the technologies' uncertainty itself diminishes the need of complicate analyses and lightens the burden of decision making on the investment. With either or both of these approaches, firms could proceed effectively to the technology commercialization process.

While most of the existing studies about technology commercialization are more inclined to the first approach, the case of TOTO in this paper is well describing the second one. The case suggests that, besides what is called the analytical approach, reducing technologies' uncertainty through "learning-by-exposure" plays an important role in commercializing new technologies. In this paper, we term this second approach as "experimental approach" that represents a new perspective on the management of technology commercialization.

1. Introduction

In spite of their aggressive investment on R&D and, therefore, a constant growth of technological knowledge, Japanese companies do not always succeed in new product and business development. It is often the case that companies with rich technological knowledge do not demonstrate high performance in the marketplace. These are closely related to the fact that almost half of all technology patents that Japanese companies hold is dormant being unutilized [1]. For Japanese companies, commercializing technological knowledge effectively, rather than just creating it, has become one of the most significant strategic issues. The purpose of this paper is to explore a perspective on the management of technology commercialization process, based upon a case analysis of a successful Japanese company.

Here, we will examine the commercialization process of the light-induced wettability conversion technology in TOTO Ltd. The technology, that is called "Hydrotect" as the commercial brand in TOTO, was invented in 1995 and has brought the company more than JPY 20 billion in sales in these four years. In the fiscal 1999, the Hydrotect businesses

have accounted for as much as 5 % of the company's whole sales. To be sure, behind this is the superiority of the technology itself, but at the same time we can see an interesting approach for technology commercialization. That is, the company let the technology exposed to the public at the very early stage after the invention, through which it tried to understand the potential of the technology and appropriate directions of commercialization.

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The case of TOTO in this paper is well describing the second approach. By exposing the new technology, Hydrotect, to the public, TOTO made it possible to understand what the technology is, how promising it is, and where it can be applicable, and these provided the technology with a strong foundation for legitimating the commercialization investment.

Although many studies have been accumulated about technology commercialization thus far [2], most of them are more inclined to the first approach, insisting the importance of the development of sophisticated technology evaluation systems, careful selection of promising R&D themes through minute analysis, arrangement of close communication between research and development organizations, and so on. The case of TOTO, however, suggests that, besides that approach, reducing technologies' uncertainty through "learning-by-exposure" plays an important role in commercializing new technologies. In this paper, we called this second approach as "experimental approach", in contrast with the first "analytical approach", that represents a new perspective on the management of technology commercialization.

In the next section 2, we will consider, first, what the technology commercialization process is and why it is often so difficult for firms to pursue, presenting a conceptual framework of the process. Then, in section 3, according to the framework, two possible approaches, enhancing evaluation capabilities and reducing technology's uncertainty, for overcoming the difficulty will be addressed. Among these two, the case study of TOTO depicts the importance of the second approach and provides us with a hint to realize that approach. In the section 4, we will describe the case and discuss about its implications for the technology commercialization process. The final section 5 gives concluding remarks.

2. Difficulties in the Process of Technology Commercialization

2.1. Uncertainty of New Technologies

Technology commercialization is the process in which firms turn their technologies into products or services, or realize knowledge into profit. Firms can earn money by selling or licensing technologies in the form of patent to other organizations, but, otherwise, they have to translate them into any products or services. In this translation process, however, firms are often faced with difficulties that are mainly due to uncertainty inherent in technology and innovation process.

There are various kinds of uncertainty in the process of technological innovation. For instance, there is "technological uncertainty", concerning if new technologies would actualize their potential as those which are usable for real products or services. It is often the case with new technologies that initial performances are far worse along some important technological dimensions compared with the relevant existing technologies [3]. Even though they have higher potential, it is uncertain that they are successfully improved and actually outperform the existing technologies. Also, while new technologies are being improved, the activity itself may stimulate the improvement of the existing ones [4]. This dynamics elevates the uncertainty of new technologies. Furthermore, in the rapidly changing environment, new technologies may shortly come to be obsolete by the emergence of next generation technologies [5]. In such technological uncertainty and risks, firms are apt to hesitate to invest promptly on commercializing new technologies.

We can also point out another uncertainty, that is, "market uncertainty". Firms are always worried with questions like "Will investing on this technology really pay?" and if the answer is yes, "In which product or business field will it bear

the greatest fruit at all?". As technology is equivoque [6] and an artifact with interpretive flexibility [7] by its own nature, it can be applicable in wide range of product fields. It is not natural that an application field of technology is determined *a priori*, and that it is sure to make a profit there. Rather, technology is often introduced into an unexpected field in which it eventually comes into great flower [8]. This is also true to a market-oriented technology that is developed for a particular product goal. Technology development is a time-consuming process, and so the market needs may have already changed when a targeted technology is developed. In that case, the technology comes to be faced with the same problem as it has to find a new application field.

2.2. Limits of Opportunity Evaluation Capabilities

Here, of course, if firms had enough capabilities to appreciate exactly the potential and the opportunity of a technology, it would not be so difficult for them to make a quick decision to invest on the technology and step forward the commercialization process. In reality, however, firms are more or less bounded in such capabilities. To put it shortly, the problem of "bounded potential /opportunity evaluation capabilities" is another factor that gives rise to the difficulty in the process of technology commercialization.

Even under the bounded capabilities, a brave management might be able to propel the commercialization process by taking aggressively the risks in investing on a new technology. Although, if the investment is rewarded with success, he can leave his name in a tale of heroism of the firm, such a super-rational decision making is nothing but "a gamble" and does not always guarantee the success of commercialization.

Usually, it is not until a new technology is improved and its uncertainty is reduced to a certain degree that firms can make a sure decision of investing on a new technology. As shown in Fig. 1, firms enter upon a regular commercialization process at the point, X, where the uncertainty of the technology is reduced to the extent that firms can evaluate the potential and the opportunity of a new technology even under their bounded capabilities.

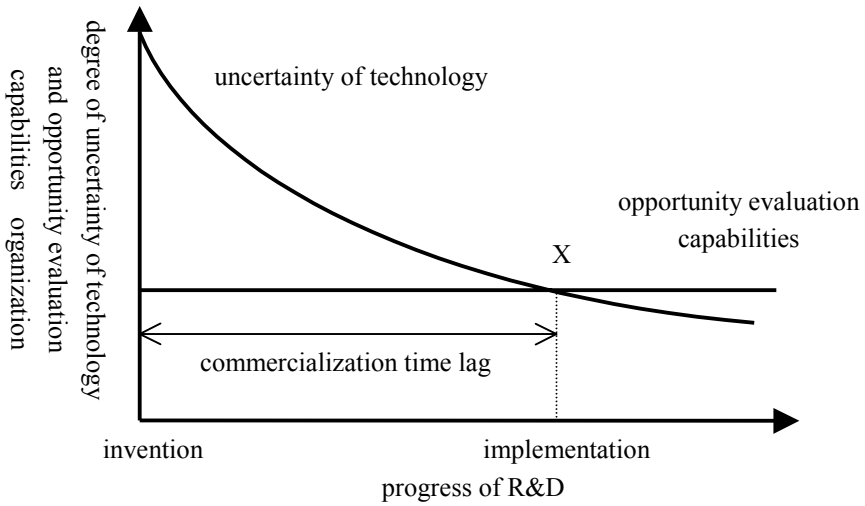


Fig. 1 Decision Making Model of Technology Commercialization

2.3. Delay and Failure in the Process of Technology Commercialization

In this meanwhile, the commercialization of a new technology is put off. Many studies have been accumulated concerning this time lag: for example, Utterback [9] pointed out that it took about 8 to 15 years from the time technology was invented and the time it was first introduced into an innovation. Also Battele Memorial Laboratories [10] has clarified that the average time lag between technological invention and its commercial production was 19.2 years [11]. According to our framework mentioned above, the lag can be interpreted as the time until the uncertainty of a new technology is reduced with progress of R&D and a firm comes to understand enough the potential and the opportunity of a new technology (see Fig.1).

The uncertainty of a new technology can be reduced with progress of R&D, but this is not always the case. Most likely, the R&D activity in this phase is something like a scanty underground works, not guaranteed with an authorized support form a firm. Therefore, learning on the technology is slow to advance and occasionally the R&D activity itself is discontinued *en route*, the result of which is that the technology is keep unutilized to be dormant. We could explain the failure of technology commercialization in terms of the "unfilled gap" between technology's uncertainty and organizational potential/opportunity evaluation capabilities.

3. Approaches for Technology Commercialization

3.1. Two Approaches

Then, what countermeasures can firms take to proceed effectively to the commercialization process under the difficulties that are caused form the technology's uncertainty and the limited potential/opportunity evaluation capabilities of the firm?

In considering this question, it would be useful to refer to the theoretical works of Galbraith [12] about organization design under uncertainty of task environment. He has pointed out that, in order for firms to keep effective and adapt to the uncertainty of task environment, two approaches are important: one is to improve firms' information processing capabilities, and another to reduce the amount of information to be processed. Even though the amount of information to be processed is constant, firms can lighten the burden of information processing activities if they can improve the processing capabilities. On the other hand, even though the information processing capabilities are limited, they can do the same thing if they can reduce the amount of information itself. With either or both of these approaches, firms can maintain the effectiveness and adapt to the environment.

Taking these arguments into the matter of technology commercialization, we can induce two basic approaches for coping with the difficulties of the process. The first is to enhance the potential and the opportunity evaluation capabilities concerning a new technology to detect analytically the value of the technology and the direction of its commercialization. And, the second is to reduce the technology's uncertainty itself to diminish the need of complicate analyses and lightens the burden of decision making in the process of technology commercialization. By enhancing the evaluation capabilities, firms can start the investment on the technologies at an earlier point of time (X' in Fig.2), through which they can shorten the time lag from invention of the technology to implementation of its commercialization. In the same way, by reducing the uncertainty itself, they can understand the potential and opportunity of the technology, through which they can set to commercialize the technologiy more quickly (See Fig.3).

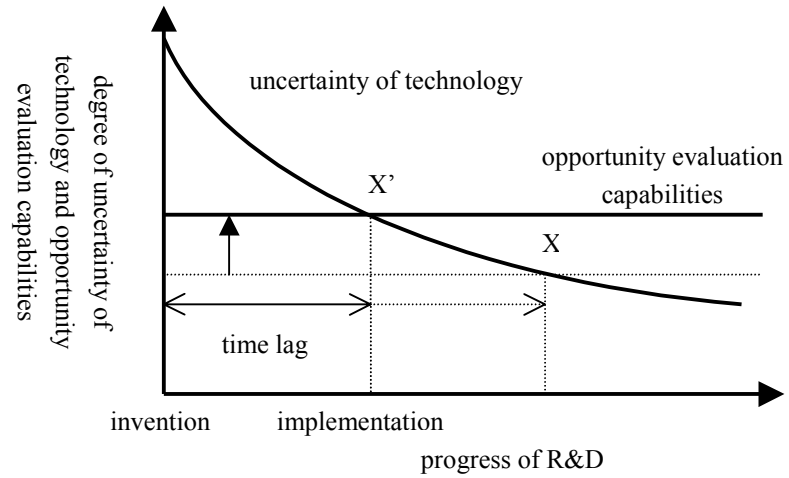


Fig. 2 Enhancement of Potential/Opportunity Evaluation Capabilities

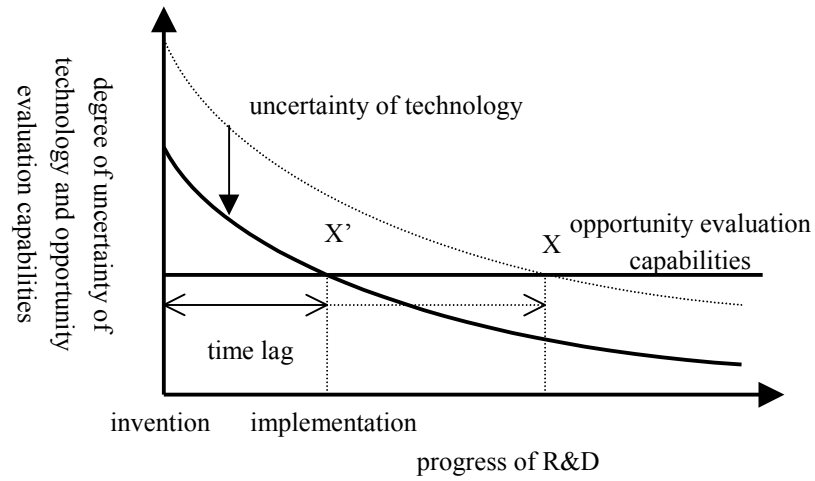


Fig. 3 Reduction of Technology's Uncertainty

3.2. Reducing the Uncertainty of Technology

As such, in order for firms to succeed in the process of technology commercialization, two approaches, or enhancing organizational capabilities to evaluate the potential and the opportunity of a new technology and reducing the uncertainty of the technology itself, are important. Of course, these can be taken substitutionally, but are most fruitful if they are taken complementarily with each other. Thus, the firms should plan and manage both approaches elaborately.

What is the point here is that most of the existing studies about technology commercialization so far have not grasped, at least explicitly, the possibility of these two approaches. They are paying more attention to the approach of enhancing evaluation capabilities, insisting the importance to establish the strong recognition of the value of technology and its transferability [13], to select carefully promising R&D themes through minute analysis [14], to arrange close communication between research and development organizations to explain and understand the potential of a new technology [15], to take advantage of IT technologies to bridge the communication barriers between those organization [16], and so on, and do not sufficiently take into consideration the approach of reducing the technology's uncertainty. As is plain from the above discussions, however, reducing technology's uncertainty, as well as enhancing evaluation capabilities, is the important approach to be considered in the process of technology commercialization, the management of which need to be explored in both fields of academy and business.

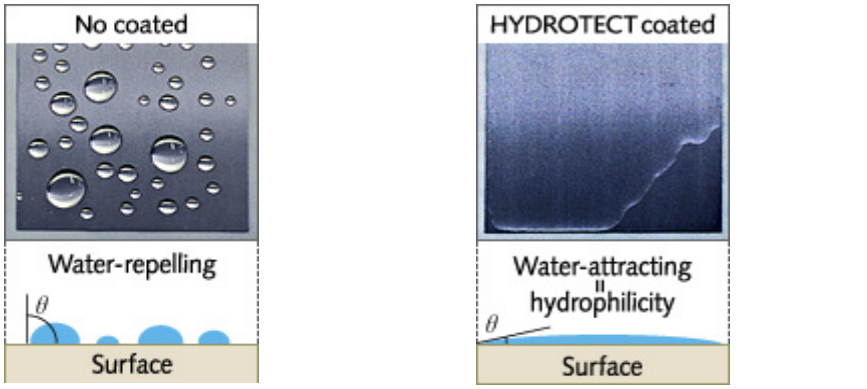
In the next section, we will consider a concrete way of the approach by examining the case of commercialization process of the light-induced wettability conversion technology in TOTO Ltd. The case will illustrate the approach well and give a hint on a way for its realization.

4. Case Study: The Commercialization Process of "Hydrotect" in TOTO

4.1. Invention and Search of Applications

TOTO is a manufacturing and sales company in Japan for, mainly, such products as bathroom, kitchen, and toilet, as well as vanity cabinets. As the leading company in the Japanese sanitary ceramics and the metal faucets industries, it has recorded about JPY 350 billion in sales revenue in the fiscal year of 1999. Although the sales are decreasing these years due to the long-standing depression of the Japanese economy, new businesses based upon new technologies are growing and sustaining the company. Among such new technologies, one of the most important is the light-induced wettability conversion technology.

The light-induced wettability conversion technology, that is called "Hydrotect" as the commercial brand in TOTO, is a technology using a novel phenomenon on photo-catalyst. That is, when the surface of photo-catalytic film is exposed to light, the contact angle of the surface with water is reduced gradually, then, reaches super-hydrophilicity. In other words, it does not repel water at all, so the water cannot exist in the shape of a drop, but spreads flatly on the surface of photo-catalyst (See Fig. 4). The technology, thus, has anti-fogging and self-cleaning properties. In TOTO, this technology was invented in 1995 and has brought the company more than JPY 20 billion in sales within these four years. In the fiscal 1999, the Hydrotect businesses account for as much as 5% of the company's whole sales.



Generally, the contact angle of the surface with water is large.

The contact angle of the super-hydrophilic surface with water is very small, so water spreads flatly.

Source: TOTO's HP on the web site: http://www.toto.co.jp/hydro_e/develop/hydro.htm

Fig. 4 Hydrotect Technology

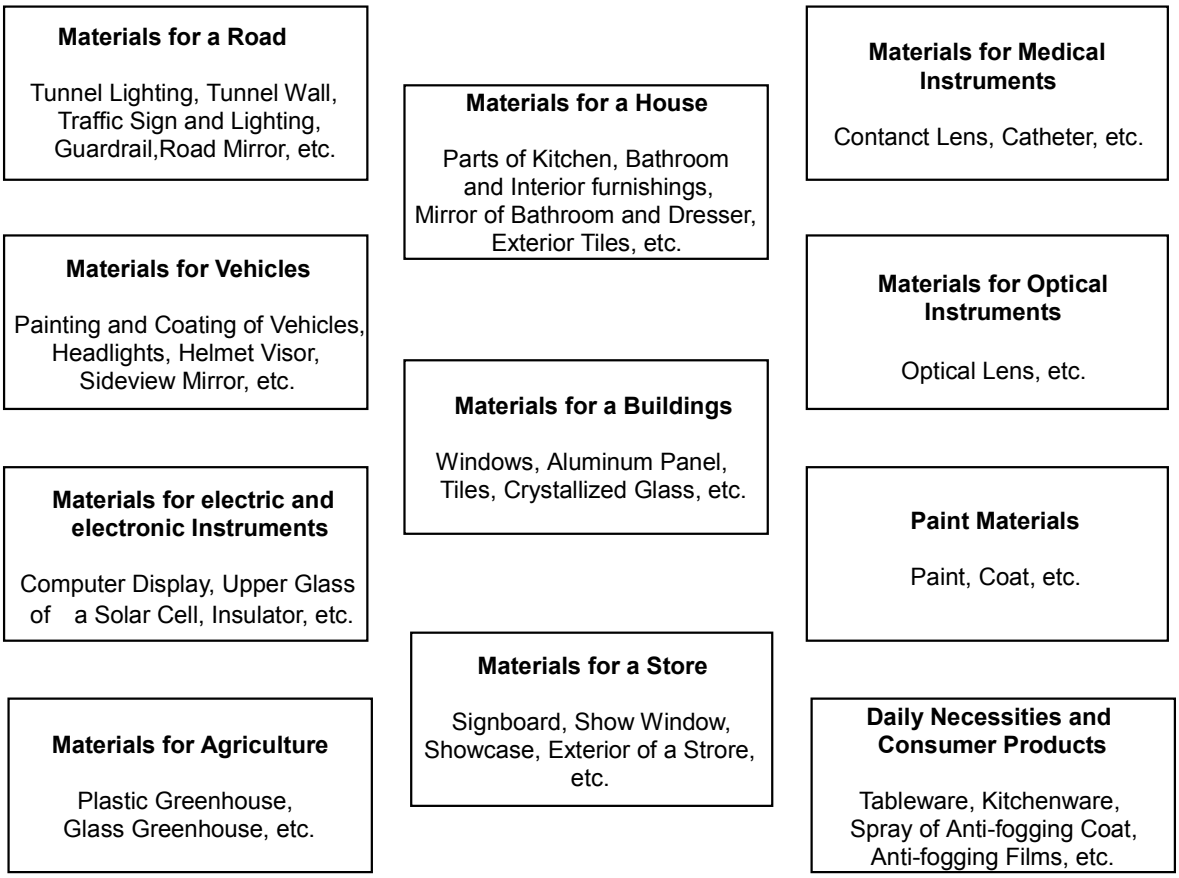
Just after the invention, the Hydrotect was regarded as a technology that can be applicable to various product and business fields. Searching out its applications with a keyword such as “hydrophilicity” revealed a broad range of application fields that might exceed the business domain of the company. If it is used merely in the existing businesses, however, the technology is no more than a material for a house, e.g. tiles and a mirror in a bathroom, and the other vast possible application fields will be abandoned. With recognizing that it was too wasteful, the researchers who invented the technology intended to develop new businesses, while applying it to the existing ones.

But, the problem here was which business would be the most appropriate and bear the greatest fruit among the vast application fields that had been revealed through the beforehand detection. Also, they understood well that it was a tough work for them to made management justify a new business development project based upon the technology and to acquire necessary resources for the project. Toshiya Watanabe, Dr., one of the researchers who invented the technology and led the project mentions about this as follows [17].

> “Even if a new business could earn JPY 10 billion, it is only one forty fifth of the total sales if the existing businesses earn, for example, JPY 450 billion. Management can not invest precious resources with high priority on such a small business. In order to acquire them, we must prepare some very good reasons to make him go down.”

4.2. Technology Exposure for Justifying Commercialization Investment

In that situation, Dr. Watanabe thought over a scheme for acquiring resources to commercialize the technology, and proposed a plan to expose the technology to the public. He thought that, by exposing the technology, he could get information about how and where it would be useful, and this would gives management a foundation for legitimating the commercialization investment. According to this plan, TOTO inserted a press release and an advertisement of the technology with a list of the possible applications (see Fig. 5) in July 1996, the next year of its invention. Moreover, it made a Home Page on the web site and opened it to the public. Consequently, the company received more than 200 inquiries just on the first day of the press release and about 600 by the end of the year.



Source: Watanabe [17], p. 19 and TOTO’s HP on the web site.

Fig. 5 Suggested Applications of Hydrotect

Of course, before the exposure of the technology, TOTO did not neglect applying for patents. In October 1996, a working group was organized around Dr. Watanabe including 6 researchers from basis research center, 2 from intellectual property division, 1 from marketing division, and the group started patent applications aggressively. More

than 70 patents, basic or peripheral, were applied for by the time of the first press release in July 1996. At present, the number of the patents goes as many as 500.

With a lot of feedback information from outside, the members of the working group came to understand more clearly which applications are promising for the technology. At the same time, they could find some new applications that had not been supposed at all before. In April 1997, they arrived at a licensing agreement with a big automobile company in Japan that used the technology as a material of an anti-fogging sideview mirror. Going through these processes, they gradually increased the evaluation of the technology and heightened the status of the commercialization activities. Dr. Watanabe explains the importance of the technology exposure in the process of commercialization as follows [18].

> "For both management and researcher, a value of a technology and its potential and opportunity are quite uncertain at the initial stage of technology commercialization. At the stage where they've not yet had a real product, they are just saying that the technology is useful or unuseful without any convincing data for judging if there is any market needs for the technology. …..However, as our case suggests, you can judge the potential and opportunity of the technology through exposing it to the public at the stage of a technology itself. This is an important point in the process of technology commercialization. In particular, when you are planning to use a new technology or develop a new business with the technology, information acquired through the exposure would be of a great value. If you have lots of feedback information about the technology and identify it to be promising, you can ease the burden of decision making on its commercialization. Had you the abundance of R&D resources, there would be no problem. But, when you have to plan on the commercialization of a new technology with limited resources, the approach of exposing it to the public and seeing a response would be an effective way."

In TOTO, a new business division, called "Frontier Business Division" was established as early as in December 1996, for developing anti-fouling and anti-fogging films, clear soundproof walls on the highway, painting and coating materials for automobiles, clear tent seats, and so forth. Also, TOTO established a new company, "Frontier Research, Co. Ltd." in May 1997 that was specialized in a licensing business of the Hydrotect technology.

4.3. Discussions

The case of the commercialization process of the Hydrotect in TOTO described above provides us with a great hint concerning a way for reducing the uncertainty of a new technology. That is, it depicts out that exposing the technology to the public and seeing a response is an important way for firms to learn about the potential and the opportunity of the technology. A new technology and its commercialization process are highly uncertain, so that even the best and brightest managers or researchers can not foresee exactly if the technology bears fruit and where it can do the best. In that situation, they can try to improve its evaluation capabilities, but at the same time they can reduce the uncertainty itself through "learning-by-exposure". If we call the former approach as "analytical approach", the latter can be called as "experimental approach" in that such learning is based upon real experiments in the market.

Behind the concept of learning-by-exposure lies an insight about the nature of technological knowledge. Like other kinds of knowledge, technology is a context-dependent entity [19] and gives a different meaning by being put into a different context. Therefore, a technology that is supposed to be excellent in a firm may not be evaluated so excellent in other firms, and a technology supposed in a firm to be useful for a certain product may be thought in a different firm to be useful for a different product. Anyway, exposing a technology to a broader context enables firms to acquire more information and perspectives on the technology and, thus, to propel the commercialization process more effectively.

In TOTO, the learning-by-exposure was conducted mainly via interactions with outside others, but it could be done within a firm, too. If the firm is diversified and has different business divisions, or different contexts, it can get information to evaluate the value of the technology by exposing it to these divisions. In fact, innovative companies like Sony in Japan and 3M in the US are circulating their technological knowledge aggressively, setting up various technical meetings and forums involving all divisions as well as affiliated companies. Although diversified, large firms sometimes have a wall between divisions, it precludes the flexibility in interpreting their technologies. Firm is a huge interpretive device in a sense, and so it shall be utilized to understand the potential and the opportunity of technologies.

The potential and the opportunity of a new technology are sometimes clear or can be explored easily in accordance with the property of the technology and the background of its creation process, but it is not always the case. Especially, what we call a core technology that is often generated from a long-term research activity and become the support of a firm later is more likely uncertain if it can really actualize its potential, and if and where it can bear a considerable profit. It is in such a technology that a firm needs most the experimental approach based upon learning-by-exposure. This is also true to some extent, however, to a market-driven technology. Even with a clear application goal, every market-driven technology can not always succeed in its commercialization. It sometimes misses the goal for some reason or other and is left unutilized. In that case, the technology is faced with the same uncertainty as a research-driven technology and needs to take the same approach for its commercialization.

Of course, in the process of technology commercialization, the analytical approach shall not be neglected. As is mentioned above, enhancing evaluation capabilities and reducing technology's uncertainty are not substitutional, but complementary with each other. A firm shall plan and manage both analytical and experimental approaches elaborately to succeed in the technology commercialization.

5. Conclusions

In this paper, we have conceptualized the technology commercialization process and the difficulties in the process with respect to the uncertainty of a new technology and the limit of potential/opportunity evaluation capabilities. And, according to the framework, we have addressed two different perspectives on managing the process effectively. The difficulties in the technology commercialization process are caused by the reality that a new technology is often highly uncertain in terms of both technological potential and market value on the one hand, and the reality that a firm is bounded in capabilities to appreciate exactly the potential of the technology and the direction of its commercialization on the other hand. Under such a situation, the firm can cope with the difficulties through enhancing the evaluation capabilities, by means of the development of sophisticated technology evaluation systems, arrangement of close communication between research and development organizations, and so on, and reducing the uncertainty of the technology itself, for example via learning-by-exposure. We have called here the first perspective as the analytical approach and the second as the experimental approach, both of which shall be exercised to succeed in the process of the technology commercialization.

Most of the existing studies about technology commercialization so far have not grasped, at least explicitly, the possibility of these two approaches. They are paying more attention to the approach of enhancing evaluation capabilities and do not sufficiently take into consideration the approach of reducing technology's uncertainty. As is plain from the case of TOTO described in this paper, however, reducing technology's uncertainty, as well as enhancing evaluation capabilities, is the important approach to be considered in the process of technology commercialization, the management of which need to be explored in more detail hereafter.

Based upon the case study, we have pointed out that exposing a new technology to the public at an early stage of the commercialization process and seeing a response to it is a possible way to reduce the technology's uncertainty. But, there would be more variety of ways to do so. With accumulating more knowledge from other cases, we shall deepen the understanding of the approach and the management of the technology commercialization process as a whole.

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