13 A Study on Strategic Use of the Patent System and Its Effects on R&D (*)

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The purpose of the patent system is to encourage invention by promoting the protection and utilization of inventions, thereby contributing to the development of industry as a whole. Consequently, when designing a patent system, it is vital to avoid negative impacts that could arise due to strategic use of the system by companies seeking to maximize profits (for example, impeding incentives for competing companies to undertake research and development, rather than increasing its own incentives to undertake research and development). The objective of this study is to analyze decision-making mechanisms in companies' strategic intellectual property protection activities (such as decisions on whether to patent or conceal an invention) and conduct a theoretical analysis of the relationship between such strategic activities by companies and the innovation performance generated in the market as a result, in order to identify issues concerning approaches to a patent system that will contribute to industrial development.

Ⅰ Introduction

Article 1 of the Patent Act clearly states that the purpose of the patent system "is, through promoting the protection and the utilization of inventions, to encourage inventions, and thereby to contribute to the development of industry." Thanks to the development of various databases in recent years, Japan is among those achieving remarkable progress in investigating innovation processes related to such issues by using patent data. However, patent data merely shows one aspect of companies' innovation activities, as only some of the inventions obtained as a result of research and development (R&D) are actually patented. For example, according to Yamauchi et al. (2012), who analyzed the Survey on Research Activities of Private Corporations conducted annually by the National Institute of Science and Technology Policy (NISTEP), around 20% of the inventions that emerged from each company's main business areas that were judged to be patentable were concealed, without any patent application being filed. Moreover, Yamauchi et al. (2014) pointed out the importance of trade secrets to small and medium-sized enterprises (SMEs) in particular as a means of ensuring appropriability. The purpose of the patent system is not only to protect inventions, but also to publish technology through patent applications and promote R&D via the use of this technology. Consequently, in considering a good patent system, it is necessary to think about incentives for companies to publish the results of their R&D.

The aforementioned single sentence of Article 1 of the Patent Act concisely expresses the fact that the patent system is a system that should simultaneously realize two concepts that could be described as polar opposites: the protection of inventions and the promotion of competition. If the protection of the inventor's rights is too powerful, distortions such as monopolistic markets could emerge, due to the impeding of competition between those who have the invention and those who do not; conversely, if the rights of inventors are disregarded and the only means of encouraging market competition is government policy, companies will become impoverished and are unlikely to become motivated to invest in innovation. Accordingly, for the patent system to achieve its purpose, it would appear to be vital to use this system to skillfully control the balance between protection and competition in industry.

As such, focusing on the multifaceted nature of the patent system, this study conducts a theoretical analysis of whether policies that affect protection and/or competition promote R&D through the use of the patent system by inventors. Particular attention is paid to the decision-making mechanism in companies' strategic intellectual property protection activities (whether to publish an invention and acquire exclusive rights by means of a patent application or to conceal that

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invention). In other words, as well as clarifying the mechanism via which the company that originally obtained an invention decides whether or not to apply for a patent, this study conducts a theoretical analysis of the effect on innovation performance throughout the market as a whole if the company did actually apply for a patent. Through this, it examines approaches to a patent system that will contribute to industrial development.

Ⅱ Model

This section sets out a model of a patent race in a market consisting of two companies, taking into account the cumulative nature of the inventions. From the perspective of the R&D promotion effect, it considers decision-making in terms of the situations in which intermediate inventions are published through patent applications.

With regard to the basic competitive background, the two companies are competing to develop a certain end product and two inventions are required to develop it (the first-stage invention and the second-stage invention). The inventions have a cumulative nature, so the first-stage invention is needed in order to create the second-stage invention, and the product using the second-stage invention is the end product, but it is assumed that an intermediate product using the first-stage invention could also be brought to market. Here, it is assumed that a patent application is required to bring the product to market, irrespective of the stage. In other words, it is assumed that reverse engineering, etc. would lead to the emergence of imitations if the invention was commercialized without acquiring rights via a patent application.

The series of events that could occur in this model begins with both companies starting to work on the first-stage invention. As time progresses, one of the two companies succeeds in developing the invention first and becomes the leading firm, so it faces a choice as to whether to apply for a patent for the first-stage invention or whether to conceal it.

Once a patent application is filed, a product using this invention will be brought to market, so the R&D competition focused on the first-stage invention will end and the R&D competition aimed at creating the second-stage invention will start. Success in creating the second-stage invention is the ultimate goal of both companies, so the company that is first to succeed in developing it following the R&D competition will file a patent application for the second-stage invention; the end product will then be brought to market and the patent race will end.

If, upon succeeding in creating the first-stage invention, the leading firm chooses to conceal this invention, the leading firm will move on to R&D focused on the second-stage invention, while the other company – that is to say, the following firm – will still be working on first-stage R&D. If, in this situation, the leading firm succeeds in developing the second-stage invention, that company will file a patent application for the second-stage invention and the end product will be brought to market, ending the patent race. However, if the following firm succeeds in creating the first-stage invention before that success, it is assumed that the following firm will be able to choose whether to file a patent for the first-stage invention or whether to conceal it. The patent application results in a product of intermediate quality that uses the first-stage invention being brought to market and the two companies compete to develop the second-stage invention; the company that wins this competition files a patent application for this invention and brings it to market, ending the patent race.

The diagram below illustrates the series of events that could occur in this model from the time that the competition between the two companies to create the first-stage invention begins until one of those companies succeeds in creating the second-stage invention. Here, when each company has itself succeeded in developing the first-stage invention, it cannot tell which of the two events inside the dotted line in the diagram has actually occurred. In other words, it is assumed that neither company knows whether it has succeeded in creating the invention as the following firm (that is to say, whether the rival company has already succeeded in creating the first-stage invention and is concealing it) or whether its own R&D has been successful before its rival's.

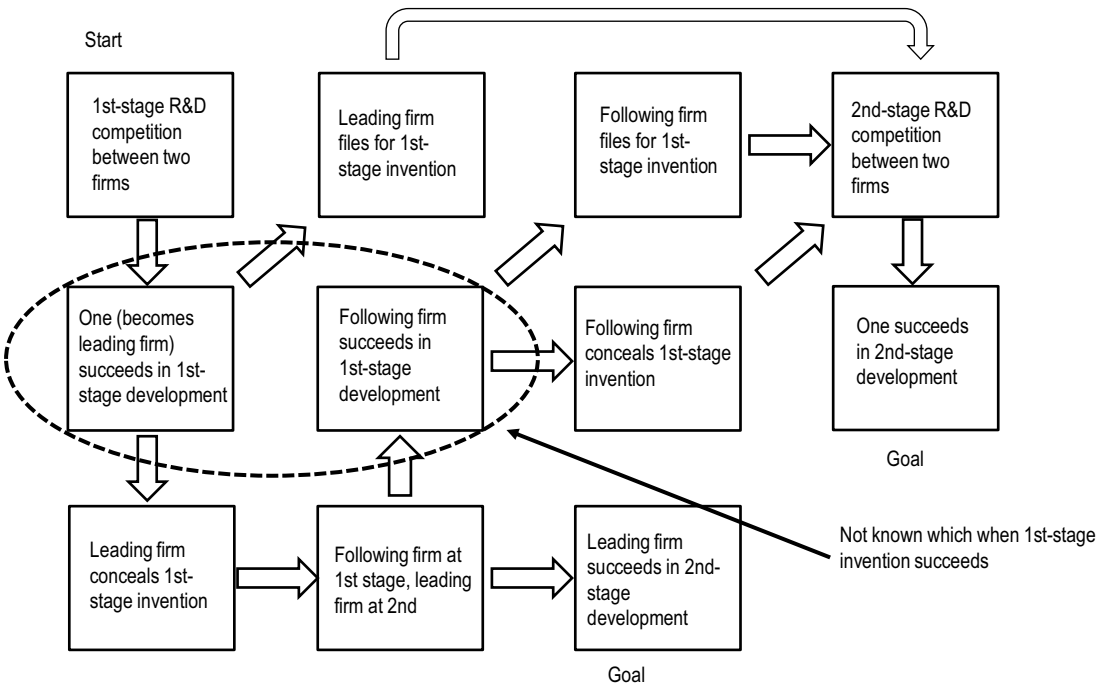

Figure 1 Series of Events that Could Occur

In each phase, each company continues to pay a certain sum in investment costs and if it succeeds in its R&D of an invention at either stage (and if the invention at that stage has not been patented by the other party), it can earn profits from the market by filing a patent application for that invention. The period during which profits are earned from the patenting of the first-stage invention runs until one of the company succeeds in creating the second-stage invention; profits from the second-stage invention can only continue to be earned for the duration of the patent protection term.

In the case of the first-stage invention, the decision on whether to file a patent application or conceal the invention is based on consideration not only of the profits to be secured from the invention, but also the ramifications of the information for competing companies (spillover) or the effect of imposing constraints on the R&D activities of the rival company by patenting the invention (blocking by such means as depriving them of freedom of operation). In this model, the ripple effect of the technology in the patent application is considered to depend on the state of the rival company's progress with its R&D. If, at the time of filing a patent application for the first-stage invention, the rival company has not succeeded in creating that invention, the ripple effect of the technology resulting from the publication of the information will enable the rival company to participate in the second-stage R&D competition without having succeeded in creating the first-stage invention; in other words, a spillover will occur. On the other hand, if, at the time of filing a patent application for the first-stage invention, the rival company is concealing the fact that it already has that invention, the information about the technology that the rival company has already succeeded in developing will be published and protected by another party, so the blocking effect will actually be greater than the spillover effect. Policymakers can control the efficiency of these effects. In the case of the efficiency of spillover, policies such as making patent examination more rigorous by, for example, adding new description requirements or revising the examination guidelines make the use of information published via a patent application more effective. On the other hand, policies affecting the efficiency of blocking focus on the extent of the scope of protection offered by a patent application.

The decisions made by companies concerning patent application versus concealment in this situation are examined. The focus here is the situation in which a patent application will be filed in a form that will result in the first-stage invention causing a spillover.

Ⅲ Solution to the Model and Effect on Policy

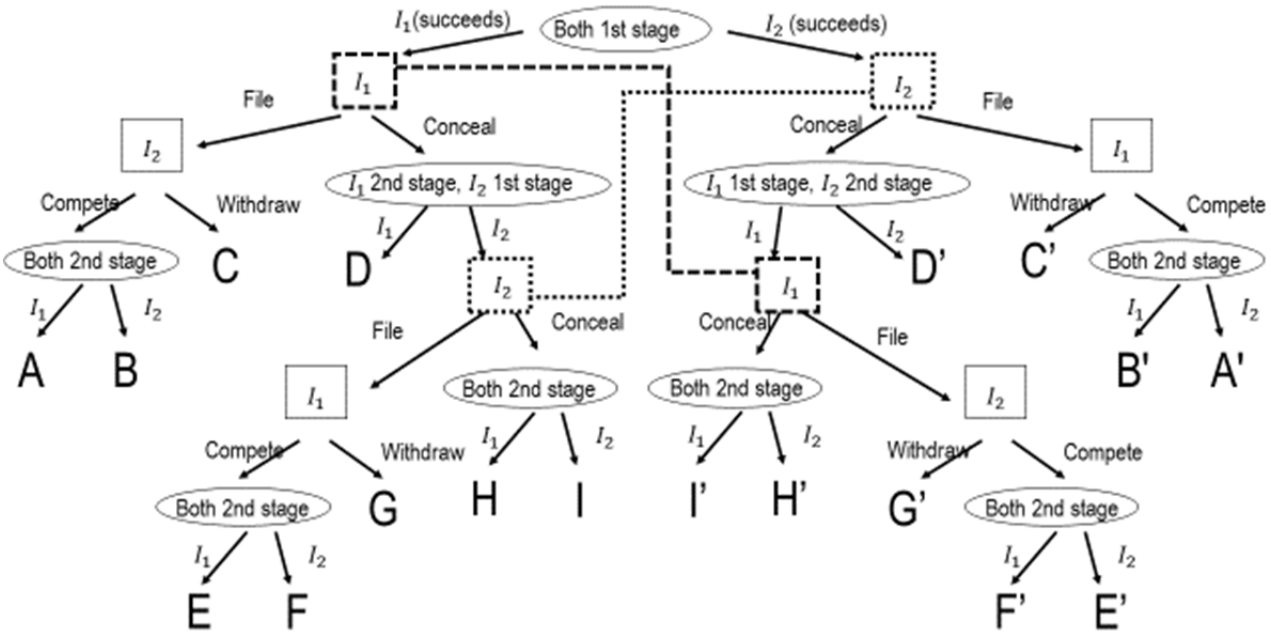

Figure 2 Two-Stage R&D Game Tree

The diagram above regards the model described in Section II as an extensive-form game with I_1 and I_2 as players, and expresses it in the form of a game tree[1]. In this model, the optimal action pairs for both companies in relation to four variables (R&D costs in each phase, the average speed at which invention takes place, the efficiency of spillover (should it occur), and the efficiency of blocking (should it occur)) are explored. R&D costs and the speed at which the invention takes place are exogenous variables that cannot be controlled by policymakers and differ according to the market in which the companies are competing. Figure 3 shows the decisions made by the companies as to whether to file a patent application for or conceal the first-stage invention in each combination of these two exogenous variables, taking the efficiency of spillover and the efficiency of blocking under current policy as a given. In the area above the dotted line in this diagram, filing a patent application is the action at the equilibrium point for both companies, but the company whose rival has filed a patent application will withdraw from the R&D competition for the second-stage invention. In the top left area of the diagram, R&D costs are high and the speed of invention is low. In this kind of market, filing a patent application for the first-stage invention makes it possible to reduce the profits that can be earned by the rival company from the second-stage invention, thereby diminishing its motivation to invest; in addition, it will take time for the next invention to be created, so it becomes more important to secure profits from the first-stage invention. Even in the shaded area adjacent to the dotted line, filing a patent application as soon the company succeeds in creating the first-stage invention is the optimal action for both companies, but here, the patent application will not cause the rival company to withdraw from the market and the consequent spillover will promote R&D competition focused on the second-stage invention. Conversely, in the bottom right area, the speed of invention is rapid and R&D costs are low, so the profits that can be gained from being the first to succeed in creating the second-stage invention are substantially greater than earnings from the market resulting from the patenting of the first-stage invention and concealment of the invention will therefore be the optimal action pair for both companies. In the portion between these two areas, the optimal action pair will be for one company to choose to file a patent application and for the other to choose to conceal it. It is not known before the R&D competition begins which company will become the leading firm, so if each company takes the action seen at the equilibrium point in this area and if the company choosing to file the application happens to be the leading firm, a technological ripple effect would occur, whereas if the following firm succeeds in creating the first-stage invention and files the application, this would have the effect of blocking the technology concealed by the leading firm.

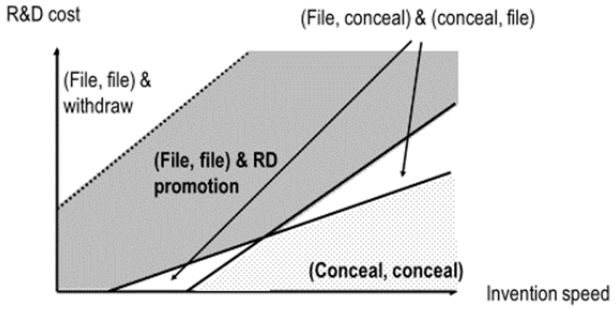

Figure 3 Optimal Action Pairs

In this model, if the action at equilibrium is (file, file) and the rival in the competition will not withdraw from the market, socially desirable R&D competition will occur at the point where the end product will be brought to market in the shortest period of time and where each company's total investment costs are lowest. Accordingly, this model examines how this desirable case (the shaded area in the diagram) can be increased by controlling the efficiency of spillover and the efficiency of blocking, which are being treated as policy variables.

The diagrams below illustrate the changes in the optimal actions for the companies brought about by a policy that increases spillover efficiency, a policy that increases blocking efficiency, and a policy that increases both of these simultaneously.

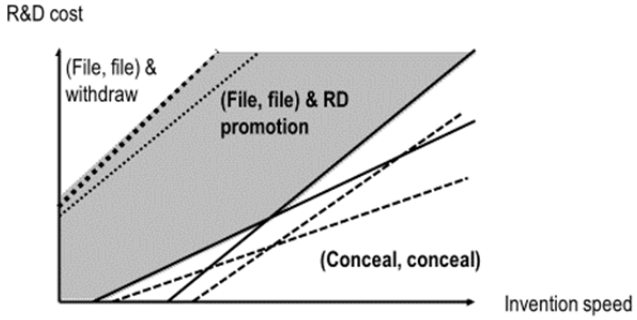

Figure 4 The Effect of Increasing Spillover Efficiency

If spillover efficiency alone increases, the number of inventions concealed due to fears about spillover to competitors will grow, while the number of inventions that encourage withdrawal from the market due to the filing of patent applications will fall. To determine whether or not there will be an increase in patent applications that promote R&D focused on the second-stage invention, it is necessary to examine the difference in size between the decline in the number of patent applications that encourage rivals to withdraw from the market and the increase in the number of inventions concealed. Consequently, a rise in spillover efficiency has the effect of shifting the area in which patent applications that encourage R&D occur further toward the top left of the diagram.

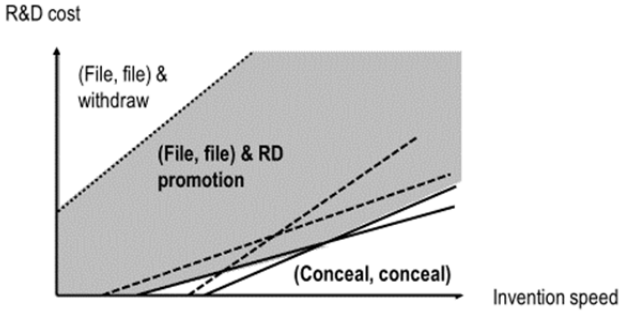

Figure 5 The Effect of Increasing Blocking Efficiency

If blocking efficiency alone increases, patent applications will begin to be filed for inventions that had previously been concealed. Rather than increasing patent applications filed in the hope of achieving a blocking effect, this increases the incentive to file due to fears of blocking by a rival. At the same time, this policy will not affect the situation in which the filing of a patent application by the leading firm causes the following firm to withdraw from the market. Consequently, a rise in blocking efficiency has the effect of extending the area in which patent applications that encourage R&D occur toward the bottom right of the diagram.

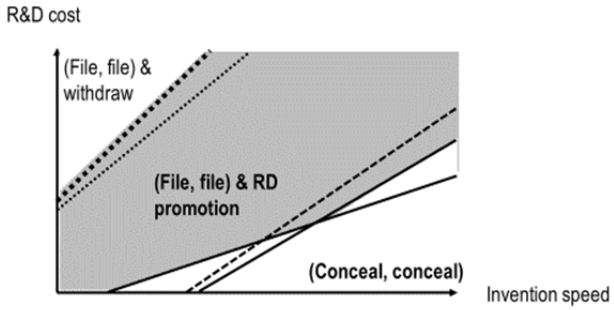

Figure 6 The Effect of Increasing Both Spillover Efficiency and Blocking Efficiency

If both efficiencies are increased simultaneously, the increased incentive for concealment caused by greater spillover efficiency can be offset by the simultaneous rise in blocking efficiency. A policy that achieves a balance in the rise in the two efficiencies brings about a strict increase in the number of patent applications that promote R&D, while causing a strict decrease in the number of inventions concealed and the number of patent applications that cause rivals to withdraw from the market.

Finally, this paper analyzes the impact that knowing whether or not the rival has an invention (in this model, a situation in which there is what is described in game theory as "complete information") has when considering whether to file a patent application for that invention or conceal it.

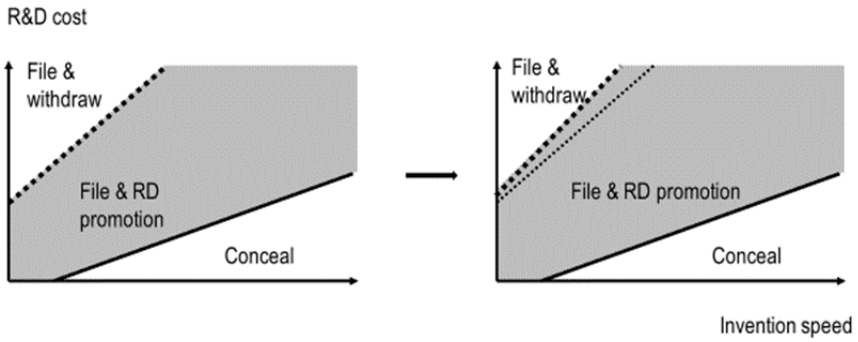

Figure 7 Changes in Actions if Both Efficiencies Increase Where There is Complete Information

The change in the diagrams above from left to right shows the change in actions by the companies if the policy in the original model changes from that illustrated in Figure 3 to that illustrated in Figure 6. Although the same policy has been enacted, in Figure 6, it had the effect of increasing the number of applications for patents in the bottom right portion of the diagram, whereas this effect is weakened where there is complete information. Accordingly, the existence of uncertainty concerning the fact that the rival might be concealing the invention can be said to increase the policy's effect. By increasing the blocking effect of patents, this policy offsets the incentive to choose to conceal an invention brought about by its promotion of the spillover effect arising from patent applications. This is because the increased blocking effect of patents increases incentives for the following firm to file a patent application due to direct motivation in the form of the ability to block its rival, whereas the leading firm will file patent applications despite the spillover risk due to an indirect factor, namely its fear that there will be a more powerful blocking effect than before the change in policy. In the situation in which a company did not know

whether it was the leading or following firm, the incentive to file a patent application was increased by both direct and indirect factors, so the companies reacted more sensitively to control of these variables.

Ⅳ Conclusion

This study considered approaches to a patent system that will encourage R&D. It focused on examining the mechanism by which companies purposely conceal inventions from which they can expect to generate profits via the acquisition of rights, and undertook a theoretical consideration of policies for reducing concealment in this situation and increasing patent applications that promote R&D. Accordingly, it firstly set out a model for actions by companies in a situation involving inventions with a cumulative nature and then analyzed the decisions they made concerning whether to disclose or conceal those inventions. From the perspective of a patent system that promotes R&D – in other words, the creation of a further invention through the utilization of a patent for which an application has been filed –this model explicitly took into consideration the intrinsically cumulative nature of inventions. As a result, it was ascertained that, due to the cumulative nature of the inventions, there was an incentive to deliberately conceal an invention for which rights could be acquired, even if there was no cost involved in filing a patent application and maintaining the patent. If R&D costs are not that high and the invention of the ultimate product will generate substantial profits, there is only a weak incentive to publish that intermediate invention in exchange for patent rights. This is because publishing it will place the company at a greater disadvantage because the rival company will learn the company's current position in the R&D competition and the direction that further development will take based on that invention. Consequently, the company is likely to want to minimize the amount of information disclosed when filing the patent application. The trade-off between the spillover effects for such rival companies and the blocking effect on the rival's R&D achieved by securing exclusive rights plays a crucial role in decisions concerning the filing of patent applications.

In the model considered in this study, both the spillover and blocking effects brought about by a patent application were explicitly examined. In particular, this model considered the effects of policies based on the assumption that the spillover effect is strengthened when an invention that nobody has previously succeeded in creating is published, whereas the blocking effect is stronger than the spillover effect if a company files a patent application for an invention that a competitor has already succeeded in developing but has been concealing, because that competitor will no longer be able to freely use the invention at hand. More specifically, if policymakers were, for example, to increase the quality of information published when patent applications for inventions were filed by imposing more stringent requirements for the description provided on the application documents, it is likely that this would increase the blocking effect of patents through controls that would make spillover occur more efficiently or by accepting a broader scope of patent protection in the claim. Accordingly, this study analyzed approaches to patent policy by using these tools in tandem, with the aim of promoting further R&D through the publication of technical information, which is the intended purpose of the patent system. As a result, it was ascertained that, rather than canceling out the effects of the policies, these two tools actually complement each other, so it is preferable to implement policies that achieve an appropriate balance between the amount of information disclosed when filing a patent application and the scope of protection provided by patent rights, according to the amount of information disclosed.

Among the various intellectual property policies that have been implemented by the Japan Patent Office, one example of more rigorous description requirements is the 2003 change in the system concerning support requirements. This change in the system took the form of the stipulation of a new type of violation of the support requirements: "When the content disclosed in the detailed explanation of the invention can neither be expanded nor generalized to the scope of the claimed invention even in light of the common general knowledge as of the filing." Accordingly, to obtain protection for the same scope as before, it became necessary to provide more detailed evidence and experimental data. If the results of the model are applied, this kind of change in the system would increase the number of inventions concealed, while reducing the number of following firms withdrawing from the market due to a patent application by a leading firm, so the balance between the two would determine whether R&D competition in the second stage would be promoted. The author would like to conduct an empirical evaluation of

such effects in the future.

Moreover, this study dealt with R&D competition between companies with the same capabilities, but in the case of competing companies with differing levels of ability to utilize patents (for example, SMEs or large corporations), even if their R&D capabilities are the same, the spillover effect of a patent application on rivals is greater for SMEs, while the blocking effect is weaker. Consequently, the incentive to file a patent application is lower than for a large corporation. The reverse could be said with regard to a large corporation, so this is likely to give rise to asymmetry between companies of different scales in terms of the importance of the patent system in securing profits from inventions.

One more distinctive feature of this study is the fact that it examined the effects of incomplete information and policy effects. Where companies are under pressure from competitors and their R&D capabilities, they do not know whether they are ahead of or behind their rivals in the R&D competition. In patent applications in this situation, there is uncertainty because the applicant does not know at the time of filing whether the application will trigger a spillover to its rivals or give rise to a blocking effect that will slow down rivals who are leading the race. This study examined the effects of policy changes in a situation where the patenting firm knows that it is in the leading position, as well as a situation where the patenting firm does not know its position in the competition. As a result, it was found that the policy effect is greater when there is uncertainty with regard to information. This is due to the fact that firms react to each of the policies because they are not sure of the effect at the time of application. Consequently, such composite policies can be expected to have a greater effect in emerging industries, where the pace of invention is swift and leapfrogging occurs frequently, with the position of leading and following firm changing rapidly, rather than in heavy industry, where the more and less leading firms are already common knowledge. This means that it is worthwhile for a company to know that it is the first-mover and that its rivals are behind in the competition. This also suggests the potential for a strategy of filing a patent that has nothing more than a signaling effect, with the sole intention of informing rivals that the company is ahead of them in the R&D competition, thereby bringing about the withdrawal of those rivals from the market without triggering a spillover effect. Models that include such options and R&D races consisting of inventions at additional stages could be topics for future consideration.

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[1] For more on game theory, see Watanabe (2008), for example. What is referred to as the information set is represented by the dotted line.