13 Impact of Licensing Schemes on the Private Value of a Patent

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The market value of technology development is affected by patent license strategies. Two patent licensing systems are commonly used: the royalty system (a patent fee payment system based on production volume) and the fixed fee system (a payment system not affected by production volume). [Kamien Tauman, 1986] (hereinafter referred to as KT) made a comparison between the royalty system and the fixed fee system and game-theoretically demonstrated that the profits gained by technology innovators under the fixed fee system are greater than those gained under the royalty system. This finding, as an economic theory, contradicts the reality that the royalty system is adopted in many cases of patent licensing. Therefore, it is important to start by examining KT's model and identify economic factors that could overturn said finding. In this study, we have analyzed the effects of various economic factors including the existence of uncertainty, possibility of in-house production, and difference in sales strategies on both licensing systems from the perspective of economics in order to determine what economic factors could limit the applicability of said KT's finding.

I Introduction

The market value of technology development is affected by patent license strategies. Two patent licensing systems are commonly used: the royalty system (volume-based) and the fixed fee system (lump-sum). Under the royalty system, royalties for a patent are collected according to the volume of products produced by use of the patent. In practice, said system is also called the rate system or volume-based system. On the other hand, under the fixed fee system, a producer who has paid a certain amount of fee is entitled to use a patented technology regardless of production volume. In practice, this system is called the lump-sum system or fixed-fee system. The purpose of this study is to mathematically (game-theoretically) identify the effects of these two licensing systems on the market value of technology development by examining the results of studies on economic theories and analyses of economic models.

The market value of technology development, i.e., the revenues gained by a patent holder through technical innovation, would vary depending on which licensing system is used, even if the licensed technologies are identical. A new technology licensed to a producer would allow the producer to lower "production costs." As a result, the producer's products produced by the new technology would become more profitable in the market than the products produced by a conventional technology. Such a difference in market profitability caused by technology innovation is the basis for the value of said innovation. The value of patented technology generated in this way is transferred to the patent holder in the form of license fees. The payment systems for license fees affect the revenues of patent holders in various ways as described below. First, in the phase of license negotiation, the most appropriate form of agreement would differ depending on which licensing system is to be used. Second, in the phase of market production, the most appropriate production method would differ depending on which licensing system is to be used. This is because "costs" for producers include not only technical production costs but also fees for the licenses necessary for production. Third, these two phases, i.e., license negotiation and market production, are interdependent.

[Kamien Tauman, 1986] (hereinafter referred to as KT) established an economic model based on two concepts, i.e., license negotiation and market production. KT used this model to compare the royalty system with the fixed fee system and demonstrated that the fixed fee system is more profitable for patent holders. This finding of KT contradicts the reality that the royalty system is adopted in many cases of patent licensing. Therefore, it is important to start by examining KT's model and identify economic factors that could overturn KT's finding. A theoretical analysis would be necessary to find a way to close the gap between KT's finding and reality. In order to carry out such analysis, three economic factors, i.e., the existence of

uncertainty, possibility of in-house production, and difference in sales strategies, must be taken into consideration. This study examines those factors from the perspective of economics.

Ⅱ Analysis by Kamien & Tauman

[Kamien Tauman, 1986] was first to analyze the relation between the profits brought by patents to technical innovators and the type of licensing system through mathematical (game-theoretical) formulation. In this attempt, they established an economic model based on two concepts, i.e., licensing negotiation and market production, and used this model to make a comparison between the royalty system and the fixed fee system in terms of license revenues obtained thereunder. Main propositions made based on the results of the comparison are as follows.

Proposition 1 [Kamien Tauman, 1986]

The license revenues obtained by a patent holder under the fixed fee system are higher than those gained under the royalty system. The difference between the two systems becomes smaller with the intensification of market competition.

In principle, they made a proposition that the fixed fee system is superior in terms of license revenues, while admitting that the difference between the two systems becomes smaller with the intensification of market competition. The economic grounds for this finding can be inferred as follows based on the mathematical structure of the model.

In the case of the royalty system, an increase in unit royalty has two effects trading off each other on the license revenues. One of the effects is that of increasing the amount of the license fee per production unit, which is a direct effect of an increasing unit royalty. The other is an indirect effect of affecting the production plan of the producer. Although the marginal cost has been reduced by a new technology, a rise in unit royalty would lead to a rise in costs of increasing production. Consequently, the marginal cost consisting of production costs and license costs would climb, reducing the benefit of the new technology for the producer. As a result, the market production volume of the producer declines after a rise in unit royalty. This would impair the use of licensed technology, having a negative effect on the license revenues.

In contrast, such trade-off does not occur under the fixed fee system because a fixed fee is a cost already determined regardless of the production plan. Therefore, a fixed fee has no effect on the marginal cost and no influence on the production volume determined according to an optimum production plan. Such a cost constantly and inevitably incurred by a producer when increasing production volume is called sank cost. Sank cost is generally known to have no effect on the optimum decision making process of an economic entity. Therefore, under the fixed fee system, a producer can enjoy the benefit of technical innovation in the form of an actual increase in market profits caused by the introduction of a new technology. This is why the revenues obtained under the fixed fee system are higher than those obtained under the royalty system, which is disadvantaged by a trade-off that could occur in the course of license fee collection.

In reality, however, the royalty system is very commonly used as a method of license fee payment. Within the framework of the economic environment presumed in KT's theoretical model, it is impossible to identify the factors causing such a wide use of the royalty system in reality. In order to identify, from the perspective of economics, the economic factors missing from the model, which cause companies to choose the royalty system over the fee fixed system, we have formulated hypotheses about each of the following three factors, which are selected as reasons for the advantage of the royalty system over the fixed fee system from the viewpoint of system users.

1 Existence of uncertainty

Usually, when a license agreement is concluded, the future market demand created by the technology in question is unpredictable. The contracting parties have to carry out licensing negotiation based on their prediction for market size. If the level of uncertainty is high, the fixed fee system would be less likely to be chosen than the royalty system, which allows the collection and payment of license fees according to the sales volume.

2 Possibility of in-house production

It is not uncommon that one economic entity doubles as a patent holder and a producer and that the patent holder itself produces products in

the market by use of the patented new technology in competition with other producers. When this is the case, in consideration of strategic interdependence in the competitive market, it would be more advantageous to impose royalties on rival producers.

3 Difference in sales strategies

In general, a low-margin high-turnover sales strategy is not necessarily inferior to the opposite sales strategy, i.e., high-margin low-turnover. The fixed fee system is suitable for cases where each producer produces products in great quantity by using the licensed technology. On the other hand, the royalty system is suitable for cases where a licensed technology is used for small volume production. Therefore, the royalty system is an effective means of selling technologies for a large number of products at a low margin.

Ⅲ Further Consideration of Each Factor

1 Existence of uncertainty

In this section, we introduced the factor of uncertainty into the model described in Chapter II and discussed cases where the future market demand created by a new technology is uncertain when a license agreement is concluded for the technology. In such cases, the royalty system may seem more advantageous than the fixed fee system because the royalty system allows the collection and payment of license fees according to the actual demand, i.e., the sales volume. However, as long as both the patent holder (licensor) and producer (licensee) face the risk of market demand uncertainty with the same frame of mind, Proposition 1 remains uncontroverted. In other words, the mere existence of uncertainty cannot explain the superiority of the royalty system for the following reason. Since the demand is predicted only as an expected value, the same mechanism as that which would be employed if the demand were predictable would cause the marginal cost to rise only under the royalty system, making the license revenues smaller than the revenues that could be obtained under the fixed fee system on average.

This analysis result suggests that the mere existence of uncertainty would not constitute a theoretical explanation for superiority of the royalty system. The analysis result was derived based on extremely simplified conditions where both the licensor and licensee face the risk of uncertainty with the same frame of mind. Therefore, in order to consider the existence of uncertainty as a reason for an advantage of the royalty system, it is necessary to take into consideration the aforementioned conditions in addition to the analysis result described above.

2 Possibility of in-house production

So far, our analysis has been based on the presumption that a patent holder and a producer are different economic entities. In an actual economy, however, a patent holder itself often produces products in the market by using the patented new technology and competes with other producers. [Wang, 1998] applied the model described in Chapter II to cases where a patent holder engages in in-house production and made a comparison between the fixed fee system and the royalty system. The results of comparison are as follows.

Proposition 2 [Wang, 1998]

If a patent holder produces products by using the patented new technology and participates in the market as a producer, the total of license revenues and market profits obtained by the patent holder can be higher under the royalty system than those obtained under the fixed fee system.

This means that the aforementioned finding of [Kamien Tauman, 1986] could be overturned in cases where a patent holder pursues market profits.

The reason for this finding is explained from the perspective of economics as follows. The mechanism explained in Chapter II is applicable to the case of in-house production as well. In comparison with licensing under the fixed fee system, licensing under the royalty system is more likely to cause the marginal production cost of the licensed company to rise, decreasing its license revenues. On the other hand, since a patent holder participates in market competition as a producer, licensing of the patented technology to other producers would intensify the competition among those who are entitled to use the new technology. Licensing of the new technology under the royalty system would increase the marginal production cost of rival

companies, increasing the market profits of the patent holder by easing the competition. In other words, the effect of the increasing marginal cost observed only under the royalty system negatively affects the license revenues but, at the same time, positively affects the market profits gained by the patent holder. When the positive effect is stronger than the negative effect, the trade-off between the positive and negative influences gives an advantage to the royalty system over the fixed fee system.

3 Difference in sales strategies

So far, we analyzed license revenues obtained under the optimum license agreement. However, we have not examined the characteristic of sales strategies adopted under each license system. Just as there are sales strategies for ordinary goods such as a low-margin high-turnover sales strategy, there should be sales strategies for technologies. From this perspective, the royalty system seems to be suitable for cases where the licensed technology is used for small volume production. This means that the royalty system is an effective means of selling technologies to a large number of producers at a low margin. In this section, we have presented an economic model to support this intuitive view.

In examining why KT's economic model does not support a low-margin high-turnover sales strategy, which would be adopted by an optimum agreement under the royalty system, we have found that one of the fundamental reasons is the use of a cost function with constant marginal cost in their basic model. The use of such a cost function means that the analysis is conducted on the economic presumption that a single firm has no limit to its production capacity and therefore would not see its marginal productivity decrease due to such limit. Based on this presumption, a company that has adopted a sales strategy that may be summarized as "large-volume sales to a small number of customers" would not see a drop in productivity due to the limited capacity of each producer. As a result, the superiority of the opposite sales strategy, i.e., low-margin high-turnover, would not be recognized.

The result of this analysis on production costs implies that one of the fundamental reasons for the suitability of the royalty system for a low-margin high-turnover sales strategy lies in a drop in marginal productivity. This study has proved such suitability by generalizing the cost function used in KT's model in order to introduce the possibility of decrease in marginal productivity. The result of the study has shown that, as is the case where the marginal cost is constant (linear), the license revenues under the fixed fee system are higher than those under the royalty system as long as the market is monopolistic and has only a small number of producers participating therein. As mentioned earlier, this is because the royalty system is disadvantaged by the effect of an increment of marginal cost, which is dominant in such a market. However, in contrast to a case where the marginal cost remains constant, in a competitive market with a large number of producers participating therein, the license revenues under the royalty system exceed those under the fixed fee system.

This finding may be explained as follows from the perspective of economics based on the model structure. Under the royalty system, a low-margin high-turnover sales strategy tends to be adopted in order to avoid the problem of capacity limitation (the possibility of decrease in marginal productivity) by diffusing the patented technology among a large number of producers. This allows effective production by those producers, increasing the value of the new technology in the market as a whole. The more competitive the market is, the larger the number of producers to whom the new technology could be licensed, leading to wider use of the technology. Consequently, the license revenues would grow. On the other hand, under the fixed fee system, an opposite sales strategy tends to be adopted. Under such a strategy, the number of licensees would be limited. In other words, new technology would be disclosed only to a certain degree, leading to rather monopolistic use of the technology. This would lead to mass production by each licensee, who tends to face the problem of capacity limitation as a result. An increase in marginal cost would reduce the effectiveness of the use of new technology, decreasing the value of the technology in the market as a whole. This structure explains why an increase in license revenues observed under the royalty system with the intensification of market competition is greater than that observed under the fixed fee system.

Ⅳ Conclusion

The findings and outline of analysis conducted in this study may be summarized as

follows. First, we introduced KT's research and showed that the royalty system has a structural limitation that prevents the license revenues from exceeding those that would be obtained under the fixed fee system. This limitation is caused by the effect of an increasing marginal cost, which decreases the benefit of new technology. Second, we analyzed cases where market demand is unpredictable when a license agreement is concluded, and concluded that, as long as both the licensor and the licensee face the risk of market demand uncertainty with the same frame of mind, we cannot overturn the proposition that the royalty system is inferior because of the effect of an increasing marginal cost. Third, we argued that, if a patent holder participates in the market as a producer, the royalty system would be advantageous because the effect of the increasing marginal cost observed only under said system makes rival companies less competitive. Finally, we examined the sales strategy adopted to sell technologies under each license system and identified the differences. The examination revealed that the royalty system, which is compatible with a low-margin high-turnover sales strategy, tends to be adopted in an economic environment where the market competition is intensive and marginal productivity is decreasing.