THE KOREAN ECONOMIC REVIEW
Volume 13, Number 2, Winter 1997.

ON THE ENABLEMENT FUNCTION OF PATENTS

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Disclosure requirement of patent system enables innovators other than the patentee to improve the patented technology. Starting from patentee's efforts to disclose the minimum amount of information on patented technology to avoid profit erosion from competition with improved products in the product market, we address a novel question of how to induce a patentee to voluntarily disclose the maximum amount of information on his/her invention. Based upon recent literature on patent and related innovation policy under sequential innovation it is argued that, with properly adjusted patent scope, competition policy should allow ex post *collusive agreements for production joint ventures between sequential innovators so as to encourage the voluntary disclosure of information by an early innovator to subsequent innovators.*

JEL Classification : K2, L4, O3
Keywords : Patent, Information Disclosure, Cumulative Innovation

I. INTRODUCTION

Economic analysis of patents has long been focused upon the life of patent pro-

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† We thank Ted O'Donoghue and two anonymous referees for helpful comments on the earlier version of this article. Remaining errors are, of course, ours.

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tection as a major policy instrument. Recently, however, the cumulative or sequential nature of technical progress has led many researchers in economics and law to incorporate the scope of patent protection as an important policy instrument as well as to synchronize the analysis of competition policy regarding agreements between innovators with it. Major questions addressed in existing literature involve, among others, what are the impacts of patent scope decisions upon technical progress and how to design patent scope policy for active technological improvements (Merges and Nelson, 1990, 1992; O'Donoghue et al., 1995), how to configure patent scope and competition policy to provide proper incentives for both initial and subsequent innovators through correct division of profit from the sequence of innovations (Scotchmer, 1991; Chang, 1995; Green and Scotchmer, 1995; Chou and Haller, 1996; Scotchmer, 1996), and how to induce rapid dissemination of knowledge and information embodied in innovations (Scotchmer and Green, 1990; Matutes et al., 1996).

In this article, we explore a novel question closely related to but clearly different from the last-how to induce *maximum or complete* disclosure of information about a patented innovation held by the patentee. In other words, our research question addresses one of the major underpinnings of the patent system which states that the patent discloses the private information of a patentee which would be held secret without patent system, so that the diffusion of knowledge is accelerated, further improvements of a patented innovation are encouraged, and eventually rapid economic growth is achieved. This *enablement* function (Merges and Nelson, 1990) of patents through the disclosure requirement of patent system, however, has been accepted with much skepticism. One of the major anti-patent arguments is that the patentee has some discretion in disclosing his/her innovation and might be willing to disclose the minimum necessary information required for patentability.[1] Further, the disclosure requirement can at times be applied rather loosely. A specification that describes only one working example of an innovation but that supplies less guidance on the subject matter at the fringes of the patent claim is often accepted as sufficient. In some cases, no working example is required (Kitch, 1977). Furthermore, even an extremely stringent enforcement of the disclosure requirement may not be effective in inducing maximum or complete disclosure in a patent application, since it is reasonable to assume that the patentee has informational superiority over patent examiners about the patent claimed subject matter. Despite these shortcomings and difficulties of the patent system in inducing socially desirable disclo-

[1] Eli Whitney's one of the first American patent on his cotton gin can provide an evidence of the discretion on the amount of information to disclose by a patentee. Eli Whitney was very generous in disclosing his innovation beyond what was required by patent law. His intent of generous disclosure, however, was not to freely provide the valuable information to society but to enlarge the scope of his patent protection so as to capture profits from other innovators' further improvements through patent infringement suits. If such an intent can be easily realised, an innovator may be willing to disclose generously. However, it is very difficult for an innovator to profit from subsequent innovations through infringement suits, which was exactly the case for Eli Whitney. See Scotchmer (1991) and a reference therein.

sure of information, there exist little economic analyses on the subject.

Based upon recent literature on patents and related innovation policy under sequential innovation, we try to analyze the subject and the result provides a tentative answer. We argue that, with properly adjusted patent scope, competition policy of allowing *ex post* collusive agreements or production joint venture between sequential non-infringing innovators leads to maximum or complete disclosure of socially valuable private information on the patented innovation.[2] Although the analysis of the disclosure requirement is not entirely new as noted above, our analysis differs from previous studies in that we distinguish incentive to patent from incentive to disclose. Whereas previous works implicitly assumed the equivalence between patenting and disclosing which implies that disclosure is a *de facto* requirement so that patenting naturally leads to compulsory maximum disclosure of information (Horstmann *et al.*, 1985; Choi, 1990; Scotchmer and Green, 1990), disclosure is consistent with the patentee's self-interest in our model which implies the voluntary disclosure of information in patenting.

From policy perspective, this study can provide important economic guidelines and implications for court's patent infringement decisions and government's reengineering of patent system in Korea, since in which the opening of patent court-which corresponds to CAFC(Court of Appeals for Federal Circuits) in U. S. —is planned at the beginning of March, 1998.

II. RELATED LITERATURE ON PATENT SCOPE AND COMPETITION POLICY

2.1. Concepts of Patent Scope

While the concept of length (or life) of patent proctection is sound and has been considered as the central policy instrument in the traditional economic analysis on patents (Nordhaus, 1969), what may be meant by the patent scope[3] is less clear and only recently began to receive attentions from economic literature on patent. In this section, we briefly introduce possible interpretations and measures of the scope of a patent. Regarding legal dimensions, patent scope is closely related to the "novelty" and "nonobviousness" requirement in patent law. Different authors have adopted different definitions of patent scope in their models. However, what they have in common is the patent scope's close relationship with the infringement deci-

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[2] This may seem odd since it is natural to disclose the maximum amount of information when joint venture on R&D is allowed. Our result, however, is regarding joint venture on production and we assumed implicitly that joint venture on R&D is prohibitively costly. See Chang (1995) for more on this concern. More importantly, our result is a outcome of both of the patent scope and competition policy. In our model, voluntary full disclosure is not achieved without properly adjusted patent scope even if *ex post* agreements are allowed.

[3] In the literature, patent scope is often appear as the term patent "breadth" just as the term patent life is often considered as a synonym of patent "length." We will consistently use the term patent scope but it has no intrinsic difference with patent breadth.

sions. Also note that van Dijk (1994) has distinguished patent scope from patent height, where patent scope is determined by the claims in the specification of a patent, and patent height is determined by the stringency of the novelty requirement applied by patent authority. Accordingly, our definition of patent scope coincides with that of patent height in van Dijk (1994), but the term patent scope is more widely used in the previous literature. Thus we adopted it.

First, consider the case of a process innovation, as illustrated by Denicolo (1995). Assume the same constant marginal costs c for all firms before innvation and consider the situation after one firm has made an innovation of the size of cost improvement d, i.e. post-innovation marginal costs become $(c-d)$ for an innovating firm. The scope of patent protection, suggested by Nordhaus (1972), may be measured by the fraction of the cost reduction that does not spill out as freely available technology to the non-innovating firms, i.e. the scope of patent protection can be represented by some constant θ such that $0 \leq \theta \leq 1$ with the interpretation that non-innovating firms can only use the production technology, without infringement, of costs less than $c-(1-\theta)d$. This kind of interpretation of patent scope, however, only provides a partial understanding of the patent scope and corresponds to what O'Donoghue (1996) and O'Donoghue et al. (1995) denoted "lagging" scope. While lagging scope protects against imitations, practical patent protection policy suggests that patent scope should include both lagging scope and "leading" scope where leading breadth protects against improvements.[4] Leading scope can be measured by some constant δ with interpretation that non-infringing firms cannot use the improvements of size less than δ without infringement. This implies that an innovating firm can exclude rivals for all technologies with marginal costs less than $(c-d-\delta)$ even if he does not innovate the technologies. One reason of providing leading scope, illustrated by Kitch (1977), is to coordinate innovative activity by granting the exclusive right of developing improvements on patented technology, which can avoid the possible duplication of researches. This "prospect" function is a significant backgrounds of patent system, since the conventional wisdom has focused on the "reward" function of the patent system only. Furthermore, O'Donoghue et al. have shown that leading scope is an essential complement of lagging scope for rapid technological progress under the environment of active technological improvements.

Second, consider the case of product innovation. One way of measuring patent scope is to assume the spatial quality competition model and denote the scope of patent protection as the distance between the patented product and the products that non-innovating firms can sell without infringing the patented product. This implies that the broader patent scope provides a higher demand curve for the patentee.

In addition to the above conceptualizations, Gallini (1992) has interpreted the pat-

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[4] There are some legal doctrines such as "doctrine of equivalents" and "doctrine of enablements" which support the leading breadth. See Merges and Nelson (1990) for more details which also includes cases of leading scope protection.

ent scope as the cost of imitation. Then the broader scope leads to more costly imitations by rivals and Matutes et al. (1996) propose the interpretation closely related to the above mentioned prospect function of patents that the patent scope determines the number of applications of an innovation in independent markets which was reserved for the patentee.

Considering all these interpretations, we consider both (complete) lagging breadth (which corresponds to the case of $\theta = 0$ in the above discussion) and leading breadth in our two-stage model and denote it by β where $\beta = 0$ implies no leading breadth.

2.2. Competition Policy as a Part of Innovation Policy

Question of defining clear boundary of technology or innovation policy is always problematic since any economic policy, though it does not directly aim at technology, indirectly influences the pace and performance of innovative activity. In line with this problem, competition policy, the regulations and statutes that govern the competition among firms, has not been considered as a major part of innovation policy.[5] Although competition policy has been mainly considered as an area in which the conflict between static and dynamic efficiency is important, Ordover and Baumol (1988) argue that this conflict is exaggerated. They nevertheless conclude that competition policy should favor innovation and dynamic efficiency over static concerns when they clash.

For examples of competition policy as an important part of technology policy, a hallmark of Japanese industrial and technology policy is the balancing of cooperation in technology creation or adaptation with strong competition among firms in the application of these technologies. In the U.S., antitrust statutes and enforcement have been relaxed over the past decade. The NCRA(National Cooperative Research Act) of 1984 reduced antitrust penalties for registered cooperative research joint ventures. More recent proposals for further relaxation of antitrust prohibitions against production joint ventures have received considerable support, culminating in the 1993 passage by the U.S. Congress of a bill to reduce antitrust penalties for registered production joint ventures.

Significance of competition policy as a part of innovation policy can be highlighted under the circumstance of cumulative innovation. As Scotchmer and Green (1995), Chang (1995) and Chou and Haller (1996) have emphasized, the cumulative nature of technological progress pushes heavy pressure on the appropriate division of profits between sequential innovators, which could not be achieved with patent policy alone, and competition policy regarding agreements between innovators should play a complementary role of providing appropriate profit division. In this

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5 Origin of competition policy as a part of innovation policy can be traced back to Schumpeter (1943) where it was argued that "bigness and fewness encourage invention." There are by now a huge empirical literature on this Schumperterian hypothesis. See Cohen and Levin (1989) on this literature.

study, we extend the role played by competition policy, namely, to disseminate technological knowledge embodied in a patented innovation.

III. THE MODEL

Consider the following modified version of a previous model by Chang (1995).[6] There are two firms with two periods of equal length with no discounting. At the beginning of the first period, an idea for an innovation-product 1—occurs exogenously to firm 1 which has value v_1 and this is equal to consumer's willingness to pay. Assume that consumers are identical and each demands one unit of the product per period. At the start of the second period, if and only if firm 1 develops the first product, an idea for product 2 occurs exogenously to firm 2 which has the value of consumer's willingness to pay v_2. The R&D cost is c_1 and c_2 for firm 1 and firm 2, respectively. There is no other substitute for these products and once either product is developed it can be produced at zero marginal cost. Both firms are risk neutral and base their investment decisions on expected profits.

At the time of their investment decisions, firm 1 knows the value and R&D cost of its own innovation with certainty and the information available to firm 2, but firm 1 does not possess the capability of developing product 2, and firm 2 knows its R&D cost with certainty but only knows that the value of its innovation, v_2, is uniformly distributed in the interval $[\alpha v_1, 1]$ where α indicates the degree of the information disclosure by firm 1 and $0 \leq \alpha \leq 1$. This implies that if firm 1 discloses only the minimum amount of information necessary for patentability, that is $\alpha = 0$, the second firm gets an idea with its value distributed in the interval $[0, 1]$ and as firm 1 discloses more information the distribution becomes truncated and the expected value of the second innovation increases monotonically.[7] [8] Innovation policy, composed of patent scope and competition policy, affects revenues available to

[6] Two-stage model applied here has been widely accepted when applying to sequential innovation. Examples include Scotchmer and Green (1990), Green and Scotchmer (1991) and Choi (1990).

[7] Previous literature on the disclosure requirement of patent system implicitly assumed the natural and/or compulsory disclosure of maximum amount of information in patenting, that is, $\alpha = 1$. Our major premise is, however, such a complete or maximum disclosure is not consistent with the patentee's self-interest because of the possibility of profit erosion through competition with improved products so that innovation policy should be configured to provide the incentives for voluntary disclosure. Also note that the right extreme of the domain of v_2, which represents the value of the ultimate possible future innovation, is normalised to 1. Alternatively, one can set this value as V, and then interprets v_1, v_2 and c_1, c_2 as relative values to V_2.

[8] In this interpretation, disclosure of information implies both of reduction of uncertaintly and rising of expected value of the second innovation. On the other hand, disclosure may imply only one of these such as mean-preserving reduction in variance. Our assumption is stronger than the assumption of the first order stochastic dominance. We thank an anonymous referee for commenting on this. Our result, however, do not directly depend upon this. Further it may seem natural that the disclosure of information affects the innovation costs of subsequent innovators as was in Scotchmer and Green (1990). In our model, slight modification of relevant parameters and variables can serve as a model of such an interpretation and we adopt our interpretation for analytic convenience.

innovators in the following way. If firm 1 patents the first innovation, it obtains a monopoly over product 1 and charges a price equal to consumer's willingness to pay v_1 in period 1. If firm 1 does not patent after development of its innovation, the innovation becomes available to the public without cost and then Bertrand competition leads to zero profit. This implies that firm 1 should patent upon the development of product 1 since firm 1 cannot engage in the second period R&D. If firm 2 develops product 2, revenues depend upon whether the second product infringes the first, which is in turn determined by the patent scope and type of agreement allowed by competition policy.

Following Green and Scotchmer (1995), we assume that infringement decision is based upon the patent scope and that the policy adopts the cutoff rule such that the patent scope can be represented by a scalar β with interpretation that the second product infringes the first if and only if its value v_2 is less than or equal to $v_1 + \beta(1-v_1)$ where $0 \leq \beta \leq 1$.

Competition policy means the treatment of various kinds of agreement between innovators by the policy authority. There can be two kinds of *ex post* agreements, which occur after the R&D cost of firm 2 is sunk, depending on whether or not the second product infringes on the first.[9] We label agreement under infringement as *ex post* "license" and that under non-infringement as *ex post* "collusion". Then there can be three types of competition policy with increasing stringency-no agreement is allowed (denoted N),[10] only *ex post* license is allowed (denoted L) and both *ex post* license and *ex post* collusion are allowed (denoted C).[11] If the second product infringes on the first, then firm 2 cannot market it without an ex post license with firm 1. If *ex post* collusion is allowed, two firms can join their interests by forming production joint venture and avoid profit erosion through product market competition in the second period. If two products compete in the product market, which occurs when non-infringing second product is developed by firm 2 and an ex post collusion or production joint venture cannot be formed, then we assume that Bertrand competition leads firm 1's profit to zero and firm 2's profit to $(v_2 - v_1)$.

Finally, assume that firms evenly divide the bargaining surplus in any agree-

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[9] We do not consider an *ex ante* agreement, which occurs before the R&D cost of firm 2 is sunk and corresponds to the research joint venture between sequential innovators, since there exists no bargaining surplus in an *ex ante* agreement under the welfare maximizing innovation policy in our model. Further, such an agreement is practically very difficult to arrange as was discussed in Chang (1995). Inclusion of the possibility of an *ex ante* agreement obscures the subject matter, because the problem of voluntary disclosure of information links to the functioning of a research joint venture rather than the functioning of patent system.

[10] We include this policy in order to emphasize the positive effect of various kinds of *ex post* agreement on the enablement function of patents. This policy is hypothetical and may not reflect current competition policy since the policy authority can recognize that if no agreement is allowed, some socially valuable innovations will be deterred. This is precisely the case in our model.

[11] In reality, *ex post* licenses between innovators often occur in the case of blocking patents. In such a case, holder of a dominant patent cannot market the improvement of the subservient patent and the holder of a subservient patent cannot market the improvement, without a consent of each other.

ments, that is, the parties reach the Nash bargaining solution.

IV. ANALYSIS AND RESULT

Since prices in each period do not exceed v_1 and v_2, respectively, there will be no deadweight loss in our model with given unit demands and the policy will affect social welfare only through incentives for firms to innovate and the amount of information disclosed by firm 1.

In our model as well as in Green and Scotchmer (1995) and Chang (1995), no innovation policy can offer firm 1 the full social surplus from his/her innovation and we will focus upon innovation policy that can introduce all socially valuable innovations while inducing the complete or maximum information disclosure of an initial innovator.

Let π_1^j and π_2^j denote the expected profits for firm 1 and firm 2, respectively, if they both decide to invest in R&D under a given innovation policy of patent scope β and competition policy $j(j = N,L,C)$. Then these profits become as follows (see appendix for derivations).

$$\pi_1^N(\alpha, \beta; v_1) = (v_1 - c_1) + \{v_1 + \beta(1 - v_1) - \alpha v_1\}v_1/(1 - \alpha v_1) \tag{1}$$

$$\pi_2^N(\alpha, \beta; v_1) = \{(1 - v_1)^2(1 - \beta)^2\}/\{2(1 - \alpha v_1)\} - c_2 \tag{2}$$

$$\pi_1^L(\alpha, \beta; v_1) = \pi_1^N(\alpha, \beta; v_1) + (1 - v_1)^2\beta^2/\{4(1 - \alpha v_1)\} \tag{3}$$

$$\pi_1^L(\alpha, \beta; v_1) = \pi_2^L(\alpha, \beta; v_1) + (1 - v_1)^2\beta^2/\{4(1 - \alpha v_1)\} \tag{4}$$

$$\pi_1^C(\alpha, \beta; v_1) = \pi_1^L(\alpha, \beta; v_1) + v_1(1 - v_1)(1 - \beta)/\{2(1 - \alpha v_1)\} \tag{5}$$

$$\pi_2^C(\alpha, \beta; v_1) = \pi_2^L(\alpha, \beta; v_1) + v_1(1 - v_1)(1 - \beta)/\{2(1 - \alpha v_1)\} \tag{6}$$

By partially differentiating the profit function of firm 1, one can easily verify the impact of patent scope and competition policy upon the incentive to disclose information of an early innovator. With properly adjusted patent scope, any kind of *ex post* agreement have an important salutary effect upon the degree of information disclosure. Further, the patent authority could be more flexible in choosing patent scope to encourage the disclosure of information by an early innovator under competition policy C than under competition policy L.

Based upon the above discussion, the problem can be defined as whether it is possible to introduce all socially valuable innovations and concomitantly induce complete information disclosure of an early innovator. If both objectives can be achieved by allowing only *ex post* license and properly adjusting patent scope, then competition policy should prohibit *ex post* collusion in favor of consumer protection. We show that this is typically not the case and competition policy should allow *ex post* collusion in order to introduce all socially valuable innovations into the market and to induce maximum information disclosure. Assume the followings :

Assumption 1. $2v_1 \geq c_1$
Assumption 2. $v_1 + 2c_2 \geq 1$

Assumption 1 implies that the initial innovation alone is socially valuable and that if firm 1 can be a two period monopolist then firm 1 will always develop the innovation. Assumption 2 implies that if patent scope β is set equal to zero and complete information disclosure is achieved, that is $\alpha = 1$, then firm 2 will always develop the second innovation, whether or not *ex post* collusion is allowed. In this case *ex post* license becomes irrelevant. If this condition is not met, competition policy should always allow *ex post* collusion to introduce the second innovation into the market and the analysis becomes trivial. Note also that these two assumptions guarantee that the maximum expected social surplus that can be realized from both innovations are nonnegative. To see this, let $SW(\alpha)$ denote the expected social surplus that can be generated from both innovations when firm 1 decides to disclose at the level α. Then,

$$SW(\alpha) = (v_1 - c_1) + ((1 + \alpha v_1)/2 - c_2)$$

and

$$Max\{SW(\alpha)\} = SW(1) = (2v_1 - c_1) + ((1 - v_1)/2 - c_2) \geq 0$$

where the last equality follows from assumptions (1) and (2). The following proposition states the main result of the analysis.

Proposition 1. *By adjusting patent scope β^* to satisfy $(1 - v_1)\beta^{*2} - 2v_1(1 - \beta^*) = 0$ and allowing* ex post *collusion between innovators, all socially valuable innovations can be introduced with maximum disclosure of information.*

(proof) Note that with patent scope $\beta = \beta^*$, firm 1 is indifferent between all possible values of α so that firm 1 will be willing to disclose the maximum amount of information, that is, $\alpha = 1$. Further, note that when $\beta = \beta^*$ and $\alpha = 1$, firm 1's profit is nonnegative. Therefore, if firm 2 always invests when $\beta = \beta^*$ and $\alpha = 1$, for all possible values of v_1 and c_2, all socially valuable innovations are introduced. Then,

it is sufficient to show that firm 2's profit is nonnegative when $\beta = \beta^*$ and $\alpha = 1$, for all possible values of v_1 and c_2. This can be shown as follows.

$$\begin{aligned} \pi_2^q(1, \beta^*; v_1) &= (1 - v_1)/2 - (1 - v_1)\beta^{*2}/4 + v_1(1 - \beta^*)/2 - c_2 \\ &= 4\{2(1 - v_1 - 2c_2) + 2v_1(1 - \beta^*) - (1 - v_1)\beta^{*2}\} \\ &\geq 4\{2v_1(1 - \beta^*) - (1 - v_1)\beta^{*2}\} = 0 \end{aligned}$$

Q.E.D.

Above proposition implies that by allowing *ex post* collusion between sequential innovators and adjusting patent scope properly, socially valuable private information of an initial innovator can be voluntarily and completely disclosed, and sequential innovators always invest if their innovations are jointly socially valuable. By disclosing his/her information, an initial innovator faces two opposite effects. It decreases the probability of infringement and consequently decreases his/her expected profits in the second period, but at the same time it increases the bargaining surplus in an *ex post* collusion. If sufficient scope of patent protection is guaranteed, the second effect dominates the first and the innovator prefers enlarging the size of bargaining surplus and capturing half the bargaining surplus to keeping its innovation secret. Note that under the innovation policy proposed in the above proposition, social welfare is maximized, that is equal to $SW(1)$. Further the policy authorities need not know the R&D costs of innovators. Thus, implementation of the policy requires only the value of the first innovation. Indeed, if patent and competition authorities can observe both the value and R&D cost of innovators, policy could allow *ex post* collusion case by case. However, R&D costs are very difficult to observe and/or verify and we assume it is the typical case. Finally, note that competition policy of allowing only *ex post* license cannot introduce all socially valuable innovations with complete disclosure of information by an initial innovator. For example, let $v_1 = 0.2$ and $c_1 = c_2 = 0.39$, then one can easily show that there will be no innovation policy which introduces both innovations with complete disclosure of information (and then socially valuable).

Ⅳ. DISCUSSION AND CONCLUSION

One of the major foundations of the pro-patent arguments is that patent enables innovators other than the patentee to improve and advance the patented technology through the disclosure of information by the patentee which would be held secret without patents. In this article, we have addressed a novel question related to this enablement function of patents. Contrary to the previous literature on patents, we have taken the position that the complete or maximum disclosure of information by the patentee is not consistent with his/her self-interest for fear of profit erosion through competition with improved products, and focused upon the innovation policy which provides the incentives for such complete disclosure to the patentee. By exploring the interactive role of patent scope and competition policy, we have shown that, with properly adjusted patent scope, competition policy of allowing *ex post* collusive agreement between sequential non-infringing innovators, corresponding to joint ventrue in production, has an important salutary effect on the incentives for information disclosure of an early innovator and consequently contributes to the enablement function of patents.

In relation to prior economic literature on patents, our result expands the role of patent scope under the environment of sequential or cumulative innovation. While patent scope is considered primarily as an instrument of dividing profit between sequential innovators in the previous literature (Green and Scotchmer, 1995; Chang, 1995; Chou and Haller, 1996), we have argued that the patent scope has another important and complementary role of providing incentives for information disclosure to an early innovator. As to the patent law literature, our result provides a novel economic rationale in applying and interpreting "doctrine of enablement" and "doctrine of equivalents" to court's infringement decisions (Merges and Nelson, 1990).

One caveat applies, however, just as in most other economic literature on patents and competition policy, that policy should be interpreted with careful consideration of the balance between static and dynamic efficiency. Following the approaches and views taken in the recent related literature, we have excluded the tradeoff in a model by assuming Bertrand competition between innovators. An analysis that drop out the assumption of Bertrand competition can provide more robust policy implications but it is beyond the scope of current model. One point to note is that, though the relaxation of competition policy is at an extensive debate, Ordover and Baumol (1988) have argued that competition policy should favour innovation and dynamic efficiency over static concerns when these clash, and our result and proposed policy can be considered in accordance with such an argument. Finally, our result is consistent with and provides a partial support for recent proposals for relaxation of antitrust prohibitions against joint ventures in production, culminated in the 1993 passage by the US. Congress of a bill to reduce anti-trust penalties for registered production joint ventures.

We conclude with possible directions for further research. Firstly, a model which incorporates the tradeoff between static and dynamic efficiencly should be developed and analyzed which can serve as a more general policy framework. Secondly, empirical justification of policy implications of patent scope and related competition policy should be an important research arena. For example, it has been widely accepted that Japanese patent policy adopts a significantly narrower scope than U. S. patent policy and Japansese technology policy has taken relatively lax treatment about production and/or research joint ventures. (Scotchmer and Green, 1990) Comparative empirical investigation of the impact of such a different policy perspective on the national innovative performance should genereate further insights about innovation policy

APPENDIX

Derivation of profits in (1) through (6) is as follows.
First define the following events which are mutually exclusive and exhaustive about the result of firm 2's R&D.

X: Firm 2's R&D results in a product of value less than or equal to v_1.

Y: Firm 2's R&D results in a product of value greater than v_1 but infringes the first product.

Z : Firm 2's R&D results in a product which does not infringe the first product.

Then, the probability of each event becomes as follows.

$$P(X) = (1-\alpha)v_1/(1-\alpha v_1) \tag{A1}$$
$$P(Y) = \beta(1-v_1)/(1-\alpha v_1) \tag{A2}$$
$$P(Z) = (1-\beta)(1-v_1)/(1-\alpha v_1) \tag{A3}$$

A-1. Profits under competition policy N.

By definition, π_1^N and π_2^N are as follows.

$$\pi_1^N(\alpha, \beta; v_1) = (v_1 - c_1) + (P(X) + \mathrm{P(Y)})v_1 \tag{A4}$$
$$\pi_2^N(\alpha, \beta; v_1) = P(Z)\{E(v_2|Z) - v_1\} - c_1 \tag{A5}$$

Conditional expected value given no infringement is as follow.

$$E(v_2|Z) = E(v_2|\, v_2 > v_1 + \beta(1-v_1)) = \{(1+v_1) + \beta(1-v_1)\}/2 \tag{A6}$$

Substituting (A1), (A2) into (A4), and (A3), (A6) into (A5) yields the required results of profit in (1) and (2).

A-2. Profits under competition policy L.

Let BS^L denote the expected bargaining surplus in an *ex post* license. Then BS^L becomes as follow.

$$BS^L = \{E(v_2 \mid Y) - v_1\}\mathrm{P(Y)} = (1-v_1)^2\beta^2/\{2(1-\alpha v_1)\} \tag{A7}$$

Since two firms evenly divide the bargaining surplus of (A7) in an *ex post* license, the required results of profits in (3) and (4) follow.

A-3. Profits under competition policy C.

Let BS^C denote the expected bargaining surplus in an *ex post* collusion. Then BS^C becomes as follow.

$$BS^C = P(Z)\, v_1 = v_1(1 - v_1)(1 - \beta)/(1 - \alpha v_1) \tag{A8}$$

Again, since two firms evenly divide the bargaining surplus of (A8) in an *ex post* collusion, the required results of profits in (5) and (6) follow.

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