An Economic Analysis of Patent Law Exemption for Research on a Patented Invention

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Abstract

We provide an economic analysis of having an exemption (from infringement prosecution) for the research on the patented subject matter. We examine the implications of exemption from patent infringement prosecution when technology is used for research. We show that while the exemption will increase follow-up research it cab reduce the investment in pioneering research, depending on the likelihood of a leap-frog, in the context of a pioneer-follower innovation. However we show that in the context of an infinite-horizon perpetual innovation game, where a firm is both a beneficiary (follower) and a victim (pioneer) of research exemption, the exemption will encourage innovation not only by eliminating the transaction cost and the inefficiency of double marginalization but also by enhancing the innovation incentive per se. We also find that the antitrust restriction on the agreement not to invest and on the associated reverse payment from the licensor plays a very important role in the effects of a research exemption.

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1 Introduction

A patent right is very extensive: it allows its owner to exclude others from making, using, selling or offering for sale or importing the invention defined by the patent's claims[1]. Using the other's invention for a research purpose is an infringement, which however may restrain significantly the process of cumulative innovation. Thus some form of research exemption are in place in U.S., E.U. and Japan.

In this paper we first employ the pioneer-follower model (Scotchmer (2004)) to examine the consequences of research exemption in the short run. The follower can resort to the exemption if it is available but must first obtain a license from the pioneer innovator of the technology. Exemption will increase the follower's incentive to innovate when the probability of innovating a non-infringing final technology ('leap-frog') because it can do so without a license which allows it to appropriate all the benefit of innovation. However lack of licensing will reduce the return from investment for the pioneer reducing its incentive to innovate.

We then examine the long run effect of research exemption by using the perpetual innovation model of Segal and Whinston (2007). In the long run each firm will be the incumbent (pioneer) or the entrant (follower) each period. Licensing fee from new incumbent to the previous incumbent reduces the benefit from successful innovation while increasing the profit of failing. The marginal benefit of innovating is smaller than when research exemption makes licensing unnecessary. Research exemption promotes innovation in the long run. It also increases efficiency by eliminating double marginalization and transaction cost of licensing.

Whether and how research use of patented inventions should be exempted from infringement has become an important issue in recent years. Increasing patenting of research tools and the other upstream technologies, which were part of the public domain in the past, and related legal disputes in recent years[2] have triggered the close examination of this issue.

[1] See, for an example, 35 USC 154 for US patent law.

[2] For instance, when Integra Lifesciences Ltd. sued Merck for using its cyclic RGD peptide. Merck's defense was US Patent law section 271(e)1 which exempts for certain experimental activities using patented process or material for purposes reasonably related to the development and submission of information for FDA approval (Integra vs. Merck). When Duke University defended its use of laser facility without license from its former employee physicist John M. Madey (Madey vs. Duke), it claimed that its academic research institution status allowed for research exemption.

There are two important types of exemption rules[3]: (1) experimentation and research *on* the subject matter, and (2) academic (non-commercial) research *with* the patented invention. The first rule focuses on the objective of the research using the patented technology and by definition is independent of who is doing the research. Experimentation and research on the subject matter may be done for the purpose of challenging the validity of the patent, confirming the value of the patent for the purpose of obtaining a license, research for the purpose of improving the invention, and research for leap-frogging the invention. EU and Japan have a statutory exemption on experimentation and research on the subject matter, while there does not exist such a statutory exemption in the US.

The second exemption rule uses the academic or non-commercial nature of the researcher (individual or organization) as the criterion, given that academic research generates knowledge externality. This rule can be interpreted to include non-commercial research, assuming that this can be well-defined, by business firms, not just by an academic institution. The recent U.S court decision on Duke and Madey[4], however, made it clear that the distinction by user was not intended by the US law. Such distinction does not exist in EU or in Japan either.

In this paper, we focus our analysis on the exemption for research on improving the subject matter[5]. An invention has two related but distinct uses: using the knowledge or information disclosed in the invention for its further scientific or technical progress vs. using the invention for the direct commercial application for which the patent is applied for. In the case of a research tool, the first use is using the knowledge disclosed for further improving the research tool and the latter use is using that research tool for the direct commercial use as a tool, which may result in scientific and technical progress in the other fields but not in this field. Thus, the exemption for research on improving subject matter forces the owner of the patent to give up its exclusive right only on the first use but not on the second use. Given that each inventor (or an inventing firm) is both a user and creator of inventions in the perpetual innovation process, such exemption can actually enhance the incentive for doing research in the context of perpetual R&D competition,

[3] Another rule is exemption of the use for experimentation and research related to the development and submission of information for the regulatory purpose for pharmaceutical products, which enjoys patent term extension.

[4] 307 F.3d.1351, October 2002

[5] See Nagaoka and Aoki (2006) for the analysis of exemption of academic or non-commercial researches. Briefly, exemption of research for this purpose is a very blunt tool for encouraging academic research and such exemption has a clearly negative effect on the development of a research tool.

as will be shown in this paper.

To the best of our knowledge, there are two substantive economic analysis of research exemption. The first analysis is provided by Scotchmer (2004) who uses a two stage innovation model. She has demonstrated a paradoxical result that a research exemption hurts the follower. Her analysis has two major limitations in our view. First, it precludes the possibility that a research exemption facilitates leap-frogging. The product market implementation of the improved invention may not infringe the original patented invention, if the new invention is located far from the original invention. Second, it does not analyze the issue in the context of perpetual innovation process. The latter analysis seems to be very important for analyzing the economic effect of exemption of research on subject matter. Very recently, Moschini and Yerokhin (2008) has analyzed a research exemption in the quality ladder model. They find that firms, ex-ante, always prefer full patent protection, but the welfare is higher under a research exemption if both initial and improvement costs are small. Their analysis however precludes the possibility of research licensing. We believe licensing is essential in sequential or cumulative innovation.[6]

We present a two stage innovation model with a pioneer and a follower research model in Section 2 for the short run analysis. We use in Section 3 a perpetual R&D competition model, which is often used in endogenous growth literature. Section 4 concludes, including discussion about welfare implications.

2 A pioneer and the follower research model

We consider the cumulative innovation process in which the follower uses for its research the invention disclosed by the patent obtained by a pioneer. We call the invention the production application of which will infringe the first patent as *an improvement*, and the invention the production application of which will not infringe the first patent as *leap-frogging*. When an exemption for research on improving the subject matter does not exist, the follower *must* obtain a license before

[6] After completing the draft of this paper, we have found that Gans (2005) also considers how research exemption affects innovation in the context of perpetual innovation process, using the framework of Segal and Whinston (2007) as we do. Our analysis, however, is quite different from his analysis, including the conclusion. In his formulation, the firms expect to reach licensing agreement in the future, contingent on the success of the research of the current entrant, and the current incumbent (the future entrant) pays the current entrant (the future incumbent) the licensing fee to conduct research, independent of whether the former succeeds or not.

undertaking a research, i.e., obtain an ex-ante license. Then the pioneer can coordinate the second stage research. On the other hand, when there is an exemption for research on improving the subject matter, the follower does not need to seek an ex-ante licensing agreement, even though it may choose to do so.

Let us consider the following specific model, which builds on Scotchmer (2004). The follower invests x in follow-up research (x is exogenous for simplicity), and the pioneer does not engage in such research. It will succeed with probability p and fail with probability $1-p$. When it succeeds, the invention will be an improvement which enhances the value of the pioneer's patent by v from v_0 to v_0+v with probability $1-\theta$, and it will leap-frog the first patent and achieve value v_0+w, $w>v$ with probability θ. We assume that the invention is drastic when leap-frogging[7] takes place, so that the private value of the second technology is not constrained by the competition with the old technology.[8] As result, the private value of pioneer's patent will drop from v_0 to zero.

An ex-ante license is the license which is negotiated before the follower invests, while an ex-post license is the one negotiated after the investment. If there is no ex-ante license, then the follower must obtain an ex-post license in order to implement its invention if the outcome is an improvement. If an leap-frogging is achieved, then there is no need for an ex-post license. The sequence of events is summarized in Figures 1 and 2 for the cases without and with a research exemption.

Without a research exemption (Figure 1), there cannot be any investment by the follower without an ex-ante license to invest.[9] If we denote the expected joint profit when the follower invests by π^I (I is for "integrated"),

$$\pi^I = p\{(1-\theta)(v_0+v)+\theta(v_0+w)\}+(1-p)v_0-x = (1-\theta)pv+\theta pw+v_0-x. \quad (1)$$

[7]We mean here the final technology does not infringe on the pioneer's patented technology. Of course the innovation process requires the patent for research exemption to have any significance.

[8]We do not assume a particular demand system or type of competition. Drastic means the new leap-frogging technology drives the old technology out of the market even if it is associated with monopoly pricing. This is based on Arrow's (1964) definition.

[9]Of course there may be positive probability that the follower will be found not to be infringing in court. We assume the legal costs for defense are prohibitively high relative to the probability of being found not to be infringing.

Denoting the profit of the pioneer and that of the follower by π_1 and π_2, the ex-ante licensing profits are the Nash Bargaining Solution payoffs with feasible set $\pi_1+\pi_2 \leq \pi^I$ and the threat point is the no investment allocations, $(v_0, 0)$, as long as the following positive joint profit condition (PJP) is satisfied:

$$\textit{PJP condition}: \qquad \pi^I > v_0. \tag{2}$$

This condition means that the threat point is in the interior of the feasible set. The ex-ante licensing payoffs are,

$$\pi_1^{ex-ante} = v_0 + \frac{1}{2}\left\{p\left((1-\theta)v + \theta w\right) - x\right\}, \quad \pi_2^{ex-ante} = \frac{1}{2}\left\{p\left((1-\theta)v + \theta w\right) - x\right\}. \tag{3}$$

If the *PJP condition* (equation (2)) does not hold, then there is no investment. In fact,

$$\pi_2^{ex-ante} > 0 \quad \Leftrightarrow \quad p\left((1-\theta)v + \theta w\right) - x > 0 \quad \Leftrightarrow \quad \pi^I > v_0.$$

The ex-ante licensing and investment will take place if and only if condition (2) is satisfied.[10] The two variables in brackets in the left side of each quadrant of Table 1 give the payoffs of the pioneer and the follower in the case without a research exemption, and the two variables in the brackets on the right hand side of each quadrant give the payoffs in the case with a research exemption. The latter payoffs depend on whether there is a unilateral incentive for the follower to invest, as discussed below.

If there is research exemption, the follower is able to invest without an ex-ante license. It needs an ex-post license only when it improves, instead of leap-frogging. We start with an ex-post licensing which is necessary when there is an improvement (the lower right rectangle in Figure 2), absent of ex-ante licensing. The threat-point is $(v_0, -x)$ since production is not possible without a license and the investment by the follower has already been sunk. With such an ex-post license, the follower gains only one half of the value of the improvement, v, while it bears the full cost of the research. On the other hand, the follower can gain all the monopoly profit $v_0 + w$ when it

[10] When condition (2) does not hold, the Nash Bargaining feasible set should be expanded to the convex hull of the union of the original feasible set and the threat point. The threat point will be on the Pareto frontier of the feasible set and the Nash Bargaining Solution will be the threat point, $(v_0, 0)$. This can be interpreted as "no ex-ante license" or an "agreement not to invest".

Table 1: Payoffs for the pioneer and the follower with (on right) or without (on left) research exemption .

		Joint Profit Condition	
		Increasing: $\pi^I > v_0$ (equation (2))	Decreasing: $\pi^I \leq v_0$
The unilateral incentive of follower to invest	Positive: $\pi_2^{ex-post} > 0$ (equation (5))	A [+,+] $(\pi_1^{ex-ante}, \pi_2^{ex-ante})$,$(\pi_1^{ex-post}, \pi_2^{ex-post})$	B [0,+] $(v_0, 0)$, $(\pi_1^{ex-post}, \pi_2^{ex-post})$
	Non-positive: $\pi_2^{ex-post} < 0$	C [+,+] $(\pi_1^{ex-ante}, \pi_2^{ex-ante})$,$(\pi_1^{ex-ante}, \pi_2^{ex-ante})$	D [0,0] $(v_0, 0)$, $(v_0, 0)$

Note: An antitrust restriction on agreements not to invest is binding for quadrant B so that in the case of no research exemption, the follower's investment takes place.

leap-frogs the pioneer.

The expected profits of the firms when the follower invests and obtains ex-post license when necessary (Figure 2), instead of an ex-ante license, are given by

$$\pi_1^{ex-post} = (p(1-\theta) + (1-p))\, v_0 + \frac{vp(1-\theta)}{2}, \quad \pi_2^{ex-post} = \frac{vp(1-\theta)}{2} + \theta p(v_0 + w) - x. \tag{4}$$

Note that the follower will invest, absent the ex-ante licensing, only if the following positive unilateral incentive (PUI) condition is satisfied:

$$\textit{PUI condition}: \qquad \pi_2^{ex-post} > 0 \quad \Leftrightarrow \quad p\left((1-\theta)\frac{v}{2} + \theta(v_0 + w)\right) > x. \tag{5}$$

For the ex-post license to yield positive value for the follower, x must be sufficiently small relative to the values of inventions, the probability of success and the profitability of leap-frogging sufficiently large (recall $w > v$).

If there is an ex-ante negotiation, the threat point is $(\pi_1^{ex-post}, \pi_2^{ex-post})$ if the follower invests with no ex-ante licensing and $(v_0, 0)$ if there is no investment. When the threat-point is $(v_0, 0)$, we have the same payoff as that of the ex-ante license given by equation (3). When the threat-point is the one with a potential ex-post licensing since (5) holds, there is no additional gain from the ex-ante licensing if the joint profit increases with the follower's investment, that is, if the *PJP* *condition* (2) holds, since

$$\pi_1^{ex-post} + \pi_2^{ex-post} = \pi^I.$$

The payoff with ex-ante licensing is given by equation (4) (quadrant A in Table 1).

However, if the joint profit does not increase with the follower's investment, that is, if the *PJP condition* (2) does not hold, the ex-ante agrement not to invest improves the joint profit to v_0 as long as the follower has an unilateral incentive to invest, i.e., condition (5) holds (quadrant B in Table 1).[11] Such an agreement would consist of the follower's commitment not to invest and the associated reverse payment from the pioneer to the follower. The payment is reverse in the sense that it is from a firm with the invention to the one without. Such agreement becomes attractive when the likelihood of success is low and investment cost is large, so that the joint expected payoff is larger without investment, that is, when condition (2) does not hold. The payoffs of such a no investment agreement will be,

$$\pi_1^{no-investment} = \pi_1^{ex-post} + \frac{x - p\left((1-\theta)v + \theta w\right)}{2} = (1-p\theta)v_0 + \frac{x + p\theta w}{2}, \tag{6}$$

$$\pi_2^{no-investment} = \pi_2^{ex-post} + \frac{x - p\left((1-\theta)v + \theta w\right)}{2} = p\theta v_0 + \frac{p\theta w - x}{2}. \tag{7}$$

Since $\pi_2^{ex-post}$ is positive when the follower has the unilateral incentive to invest and the agreement not to invest will be reached only if condition (2) does not hold, $\pi_2^{no-investment}$ is positive. That is, the follower receives the payment from the pioneer only because the follower agrees not to invest.

We note however that such an agreement would probably be prohibited by antitrust authorities since it constitutes a direct restriction of R&D competition. Given such antitrust restriction on the ex-ante agreement not so invest, the follower invests even if the joint profit is not increasing (that is, even if condition (2) does not hold) if condition (5) holds (quadrant B in Table 1). The payoffs are given by equation (4). With a research exemption the investment by the follower will not take place only if neither (2) nor (5) hold (quadrant D in Table 1). We make the following observation:

[11] As noted in footnote 10 allocation $(v_0, 0)$ will be the Nash Bargaining Solution when condition (2) does not hold by expanding the feasible set appropriately.

Lemma 1. *(On the follower's investment) Given the antitrust restriction on the agreement not to invest, a research exemption not only increases the possibility of the follower's investment but also makes us occasionally observe ex-post licensing.*

A research exemption always increases the possibility of innovation by the follower since the follower can strike the ex-ante agreement even if condition (5) does not hold, as long as condition (2) holds, (quadrant C in Table 1), while condition (5) may still hold even if the joint profit is decreasing with the follower's investment (condition 2 does not hold, quadrant B in Table 1). In particular, the follower invests only with a research exemption (quadrant B) when the following condition is satisfied:

$$\frac{(1-\theta)pv}{2} + \theta p(v_0 + w) > x > p\left((1-\theta)v + \theta w\right).$$

A necessary condition for this is,

$$\theta > \frac{v}{2v_0 + v}. \tag{8}$$

This condition can be satisfied when the conditional probability of leap-frogging is large, so that the prospect of sharing innovation with the pioneer due to ex-post licensing is small.

Whether a research exemption enhances the possibility of the follower's innovation (that is, whether it enables the follower's investment in quadrant B) depends on our assumption that the leap-frogging technology is drastic. If it is not drastic, the expected profit of the follower choosing the ex-post license is constrained with the competition with the pioneer even if the follower leap-frogs the pioneer. In particular, if the competition is Bertrand and the innovation process follows the quality ladder model, it is easy to show that the expected profit for the follower choosing the ex-post license is negative if the PJP condition (2) is not satisfied,[12] given that the follower has to bear the full innovation cost when it chooses the ex-post license. Thus, a research exemption does not enable the follower's investment in quadrant B in this case.

Lemma 2. *(On the payoffs of the followers and the pioneer) In quadrant B, a research exemption benefits the follower and harms the pioneer. In quadrant C, it has no effect. In quadrant A, a*

[12] We assume that all consumers are identical and have the willingness to pay v_0, $v_0 + v$ and $v_0 + w$ for three types of inventions. In the case of the leap-frogging invention, the entrant can obtain only w per consumer due to the Bertrand competition with the incumbent's inventions.

research exemption benefits the follower and harms the pioneer if and only if the likelihood of leap-frogging ($p\theta$) is large and the value of leap-frogging is large relative to the investment cost.

$$\pi_2^{ex-ante} < \pi_2^{ex-post} \quad \Leftrightarrow \quad \pi_1^{ex-ante} > \pi_1^{ex-post} \quad \Leftrightarrow \quad p\theta > \frac{x}{2v_0 + w}. \tag{9}$$

If such probability is smaller, in particular, if it is zero, a research exemption hurts the follower, as pointed out by Scotchmer (2005), because its profit at the threat point (i.e. ex-post licensing) is smaller by x, relative to that of the pioneer. That is, the threat point is $(v_0, 0)$ without a research exemption, while it is a linear combination of $(v_0, -x)$ and $(v_0 + v/2, v/2 - x)$ with a research exemption if the leap-frogging probability is zero (see Figure 2). On the other hand, when the follower invests even without a research exemption and the joint profit is decreasing (quadrant B in Table 1), the follower clearly gains from the research exemption.

The effect of research exemption on the pioneers's profit and on its innovation incentive depends ont he possibility of leap-frogging. In quadrant B, the pioneer's profit is clearly reduced by a research exemption since the joint profit is reduced and the follower gains from its investment. However, the pioneer's profit can be increased by a research exemption in quadrant A when the possibility of leap-frogging ($p\theta$) is small. As discussed earlier, if the leap-frogging innovation is not drastic, there will be no investment by the follower for quadrant B. Even in this case, a research exemption can still reduce the pioneer's profit, depending on the possibility of leap-frogging.[13]

The welfare effect of a research exemption is also ambiguous, even if we focus on the efficiency of the follow-up invention. The follower may have an excessive incentive to undertake the second stage research when there is an exemption. Even if the incremental value of follower's investment is negative (PJP condition (2)does not hold), it may still wish to invest (quadrant B) since it does not internalize the loss of the pioneer due to the leap-frogging (*business stealing effect*). On the other hand, such investment may not be excessive once we take into account the consumers' gain when investment takes place. The gain of consumers surplus due to the drastic innovation can be large enough to compensate the loss of industry profit. A robust result from

[13]The condition corresponding to equation (9) is $p\theta > x/n$ when the innovation process follows a quality ladder model.

our analysis is that the level of R&D by the follower is higher under a research exemption since an ex-ante agreement will always fill the gap when the ex-post agreement is not chosen.

We cam summarize the main findings on the effects of research exemption in the following proposition, focusing on the difference from Scotchmer (2005)

Proposition 1. *Given the possibility of a drastic innovation and the antitrust restriction on the agreement not to invest, a research exemption can significantly enhance the investment by the follower and makes us observe ex-post licensing occasionally. In particular, a follower may invest only under a research exemption if the probability of leap-frogging conditional on invention success is high. In such a case, research exemption reduces the pioneer's profit. On the other hand, research exemption can enhance pioneer's profit if the (non-conditional) probability of leap-frogging ($p\theta$) is sufficiently low.*

These results generalizes the analysis of ex-ante licensing and a research exemption by Scotchmer (2004), which rules out the possibility of leap-frogging. Without the possibility of leap-frogging, the pioneer *gains* from research exemption because the denial of ex-ante licensing induces the follower to bear the full innovation cost. However, with the possibility of leap-frogging, a research exemption *can benefit* the follower, since there is no need to obtain a license from the pioneer if leap-frogging is the outcome. With a research exemption and the antitrust restriction on the agreement not to invest, a significant possibility of leap-frogging can make the ex-post licensing a real outcome. This may be one of the reasons why we in fact observe ex-post licensing.

3 Perpetual R&D competition model

In many industries, innovation is perpetual in the sense that any innovation depends on the past innovations as its knowledge basis, and it in turn contributes to future innovations. There is no beginning and no end in the innovation process. Of course any cumulative innovation process has to start some time in history. The initial invention may, however, come from a scientific research or as a by product of a business activity of a firm, not from a purposive R&D by a firm. In such a case, what matters would be the speed of the equilibrium innovation process, as the past literature on the equilibrium Markov process has focused. In this kind of an innovation process, an exemption for research on improving subject matter does make sense, since it can help not only avoiding transaction costs of licensing for research on the subject matter and the inefficiency of double marginalization but it can also enhance innovation by increasing the difference between the return from the new innovation and that from the old innovation. The following analysis focuses on the last aspect, since the potential efficiency loss due to transaction cost and double marginalization is straight forward.

We consider a perpetual stochastic R&D innovation process, where an incumbent firm is leap-frogged by a non-infringing innovation of an entrant, and compare the equilibrium investments of the stationary Markov equilibrium with and without a research exemption, using the framework of Segal and Whinston (2007) on continuing innovation. There are two firms, an incumbent (I) and an entrant or a non-incumbent (E). We denote the continuation values by V_I and V_E. The incumbent monopolizes the product market and gets profit π^m, and (only) the entrant does research. The latter assumption is also adopted by Segal and Whinston (2007) which helps simplifying the analysis significantly (such assumption could be justified by a replacement effect when the incumbent can only realize the monopoly profit equivalent to one generation lead.) We assume that the antitrust policy prohibits the agreement between the two firms not to invest. In particular, it prevents the payment by the incumbent to the entrant for not doing research.

When the entrant succeeds in research and obtains a patent, it now becomes the monopolist in the product market but must pay a fixed proportion, a, of its monopoly profit to the patent owner (the previous incumbent). Since the monopoly profit of a firm is assumed to be constant over time in our quality ladder model due to the Bertrand competition with the previous product, any payment between players can be captured by the level of a. (We will discuss later how a is determined as an equilibrium of a bargaining process.) A research exemption would be characterized by $a = 0$. When the entrant is not successful in a research, it can continue to collect the licensing revenue of $a\pi^m$ from the incumbent since the entrant is the former incumbent. The entrant will successfully innovate with probability ϕ.[14] Its expected value is, thus,

$$\phi(1-a)\pi^m + (1-\phi)a\pi^m + \delta\left\{\phi V_I + (1-\phi)V_E\right\} - c(\phi),$$

where $c(\phi)$ is the research cost of the entrant choosing ϕ with $c'(\phi) > 0$ and $c''(\phi) > 0$ and $\delta < 1$ is the discount factor. We ignore the transaction cost and the cost of double marginalization of the patent licensing in the following analysis. An entrant chooses ϕ to satisfy

$$\phi = \Phi(w) = \arg\max_{\phi\in[0,1]} \left\{\phi w - c(\phi)\right\}, \tag{10}$$

where w is the entrant's gain from innovation and defined by,

$$w = (1-a)\pi^m - a\pi^m + \delta(V_I - V_E).$$

Given w, the innovation supply function $\Phi(w)$ gives the entrant's choice of the probability ϕ for a innovation prize w (or the expected discounted benefit from becoming a successful innovation, see Segal and Whinston 2007)). It depends only on $c(\phi)$. Given our assumptions on $c(\phi)$, it is an increasing function.

With the optimal ϕ, the following relationships hold for any a in stationary Markov perfect equilibria,

$$V_I = \phi a\pi^m + (1-\phi)(1-a)\pi^m + \delta\left\{\phi V_E + (1-\phi)V_I\right\}, \tag{11}$$

$$V_E = \phi(1-a)\pi^m + (1-\phi)a\pi^m + \delta\left\{\phi V_I + (1-\phi)V_E\right\} - c(\phi). \tag{12}$$

The equilibrium a is determined by the following game. We assume that the current incumbent has the bargaining power and makes a take it or leave to license (for a proportion of monopoly profit) before the entrant's decision on ϕ. What the current incumbent pays this period to the former incumbent has already been determined as a. We denote the licensing offer this

[14] We assume that patent royalties are contingency based, i.e., paid only when the innovation is successful. The effect of research exemption is independent of whether the payment is contingent or not although the optimal rate will differ.

period by $\widetilde{a}$, what the current entrant will pay if it succeeds and becomes the incumbent next period. Entrant's profit will be,

$$V_E(\widetilde{a}) = \phi(1-\widetilde{a})\pi^m + (1-\phi)a\pi^m + \delta\left\{\phi V_I + (1-\phi)V_E\right\} - c(\phi(\widetilde{a})).$$

Notation $\phi(\widetilde{a})$ denotes the optimal choice of ϕ given $\widetilde{a}$. Both $\phi(\widetilde{a})$ and $V_E(\widetilde{a})$ are decreasing in $\widetilde{a}$[15]. If the entrant rejects the offer, then it will use an alternative research technology which would depend on ease of leap-frogging among other factors. The value of the entrant with this outside opportunity is $\overline{V}_E$. Entrant will accept any offer such that

$$V_E(\widetilde{a}) \geq \overline{V}_E. \tag{13}$$

Joint profit when there is licensing is,

$$\pi^m + \delta(V_E + V_I) - c(\phi(\widetilde{a})).$$

This is increasing in $\widetilde{a}$. Since the incumbent appropriates all the surplus from licensing, the incumbent will offer the largest $\widetilde{a}$ that satisfies (13) in equilibrium. This game is played every period and in stationary Markov equilibrium $\widetilde{a} = a$ for all period.[16]

We further assume that (various parameters and outside opportunity are such that) $1 > 2a$. This will guarantee that the profit of the monopoly producer (licensee) is larger than the profit of the patentee (licensor).

The "innovation benefit curve" which gives the value of the innovation prize as a function of the innovation rate ϕ (Segal and Whinston (2007)) is given by substituting V_I and V_E by the

[15] $V_E(\widetilde{a})$ is decreasing assuming that the incumbent cannot compensate the entrant by (reversed) fixed payment, due to the antitrust restriction.

[16] Determination of such a is simplified by assuming that the cost of an alternative technology is constant over time. The technology itself may be different each period but its cost.

solutions of equations (11) and (12):

$$W(\phi, a) = (1-a)\pi^m - a\pi^m + \delta(V_I - V_E)$$
$$= (1-2a)\pi^m + \delta\frac{(1-2\phi)(1-2a)\pi^m + \delta c(\phi)}{1-\delta+2\delta\phi}. \tag{14}$$

We are interested in how it depends on the parameters. We take derivative with respect to a,

$$\frac{\partial W(\phi, a)}{\partial a} = -2\pi^m + \delta\frac{-(1-2\phi)2\pi^m}{1-\delta+2\delta\phi} = \frac{-2\pi^m}{1-\delta+2\delta\phi} < 0.$$

The first term is negative, since higher payment for research licensing penalizes the innovation by the entrant through reducing the current profit when the innovation succeeds and through increasing the current profit when the innovation fails. The second term is also negative if $\phi < 1/2$, since research licensing equalizes the continuation values of the incumbent and the entrant.

The equilibrium innovation is determined as the intersection of the innovation supply and innovation benefit curves in (ϕ, w) space. Innovation supply curve is increasing in w, therefore upward sloping, while $W(\phi, 0) > W(\phi, a)$ for all $0 < a < 1$. This means the equilibrium innovation is unambiguously larger when there is a research exemption, given the equilibrium stability conditions.

Proposition 2. *A research exemption increases innovation not only by eliminating the research license fee to be paid by the innovator to the incumbent but also by increasing the difference between continuation values of the incumbent and the entrant.*

Note that a research exemption will also result in lower price for consumers for each stage of innovation in a perpetual R&D competition, when a firm can avoid the inefficiency of double marginalization.

Although the above argument was for only two firms, the result can be generalized to more entrants. It is shown in the Appendix that a research exemption leads to greater innovation in the case of three firms.

The case for a research exemption becomes further strengthened when cross-industry knowledge flow is important for industrial research. This is because, when there are more licensors from whom a firm has to obtain a license, both the cost of licensing transaction as well as the inefficiency due to double, triple or more marginalization become higher as the number of licensees increase. In the presence of cross-industry knowledge flow a research exemption must be expanded from the exemption of research on the subject matter to that of research using the knowledge disclosed in the invention that is useful for improving its subject matters of the frontier inventions of the licensee industry, since such knowledge can be useful for the other technology areas as well.

The proceeding analysis also highlights the difference between a research exemption and shorter leading breadth (O'Donoghue (1998), Hunt (2004)) although both have the effect of weakening forward protection of a given patent. Research exemption may be interpreted as a way of weakening forward protection. Both shorter leading breadth and exemption changes the distribution of second innovation profit between the first and second innovators. In the case of leading breadth, however, shorter breadth allows the innovator to collect profit only for shorter periods of time meaning the size of the total profit (that is, the sum of the profits for the first and second firms) as well as distribution of profit is effected. The changes both in marginal benefit and total profit means that shorter leading breadth can be too long or too short. Research exemption, on the other hand, has no effect on the total profit itself. Since each firm is both first and second innovator (on the average), the total profit is unchanged but research exemption increases the marginal benefit of innovation. Therefore, a research exemption will always increase innovation.

The above discussions suggest that the economic effects of exemption for research on improving or leap-frogging the subject matter depend critically on the innovation process. Such exemption makes good economic sense in the context of perpetual R&D competition, since a firm can avoid incurring transaction cost for research licensing and the inefficiency of double marginalization, while it enhances the value of the success in innovation relative to that of its failure. On the other hand, a research exemption can reduce innovation by reducing the incentive of a pioneer in the context of a pioneer and a (non-competing) follower research, if the follower can easily leap-frog the pioneer.

4 Conclusion

We have examined the economic rationale of a research exemption on the subject matter. The patent laws in EU and Japan have explicit statutory provisions for such exemption, while the US law does not. We find that the economic effects of exemption for research on improving or leap-frogging the subject matter depend critically on innovation process. Such exemption enhances innovation in the context of perpetual R&D competition, not only because a firm can avoid incurring transaction cost for research licensing and the inefficiency of double marginalization, but also because a research exemption can promote innovation by enhancing the return from the success of innovation and reducing the return from the failure of the innovation. On the other hand, a research exemption may reduce innovation by reducing the pioneer's incentive in the context of a pioneer and a follower research context, even though it can significantly enhance the follower's research.

A research exemption will enhance welfare under perpetual R&D competition along a quality ladder. Since the entrant can gain only the temporary gain from its contribution to quality improvement, innovation is undersupplied. Thus, innovation takes place only when it is socially beneficial meaning there is no excessive investment. Thus more innovation from a research exemption is socially good. This is in contrast to the effect of research exemption in the pioneer and follower model. In this case, the research exemption can lead to the under investment by the pioneer firm because the pioneer' gain is constrained by the follower's success of innovation, even though his innovation has the lasting effect on the consumer welfare directly or indirectly. The best approach might be to provide a broad research exemption on the research on subject matter (more generally exemption for research using the knowledge disclosed in the invention that is useful for improving its subject matter), while stronger protection is provided for a pioneer invention in terms of the breadth of claims in the product market. The availability of broad protection of a pioneer patent ensures its profitability and encourages efficient ex-ante licensing, while the broad research exemption on the research on the subject matter will eliminate the inefficiency of multiple licensing in the perpetual innovation process and will encourage new innovation.

We have also found that the antitrust restriction on the agreement not to invest and on the reverse payment from the licensor plays a very important role in the effects of a research exemption. In the pioneer and follower model it can significantly enhance the follower's investment and makes us observes the ex-post licensing. In the perpetual R&D competition model along a quality ladder it can be a key element for enhancing the innovation process through R&D competition.

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Appendix

We can generalize the perpetual R&D competition to more than two firms. Two non-incumbent firms own the patent for which the incumbent must pay royalty. We consider three firms and three states that each firm are in, Incumbent (I), Predecessor ($E1$), and Entrant ($E0$). We assume only the Entrant innovates. If $E0$ succeeds, then $E0$ will be the next incumbent, I will become the next $E1$, and $E1$ will become the next E_0. If unsuccessful, all types remain the same type. The incumbent is assumed to pay royalty to two generations of the proceeding technologies. We also assume that $\ell = 1$ for simplicity.

The values satisfy,

$$V_0 = \phi(1-2a)\pi^m + (1-\phi)a\pi^m + \delta\left\{\phi V_I + (1-\phi)V_0\right\} - c(\phi),$$

$$V_I = \phi a\pi^m + (1-\phi)(1-2a)\pi^m + \delta\left\{\phi V_1 + (1-\phi)V_I\right\}, \tag{15}$$

$$V_1 = \phi a\pi^m + (1-\phi)a\pi^m + \delta\left\{\phi V_0 + (1-\phi)V_1\right\}. \tag{16}$$

We substitute (16) into (15). Then we solve for V_0 and V_I. We can find the innovation benefit of $E0$, $w = (1-2a)\pi^m + \delta(V_I - V_0)$ (which is a very complicated expression). The innovation supply curve is the same as with only one entrant. To determine the effect of research exemption on innovation , we are interested in how w changes with a.

$$\frac{dw}{da} = -\frac{3(-\delta+\delta\phi+1)\pi^m}{-3\delta^2\phi+3\delta^2\phi^2+\delta^2+3\delta\phi-2\delta+1} = -\frac{3\{(1-\delta)+\delta\phi\}}{3\delta^2\phi^2+3\delta\phi(1-\delta)+(1-\delta)^2} < 0,$$

for all $\phi \in (0,1)$ and $\delta \in (0,1)$. Research exemption will increase innovation and the result does not depend on the "front loading" unlike Segal and Whinston (2007). That is, it is not the ability to collect benefits earlier that makes research exemption beneficial, as would be the case for shorter leading breadth.