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Incentive to Raise Rivals' Costs: Patent Licensing in Vertically Integrated Markets*

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Abstract A key input manufacturer with a patent can raise its rivals' costs in upstream market either by raising the possibility of patent infringement litigation in case a license is not given or by raising the royalty in case a license is given to its rivals. We study under which scenarios the patent holder has more incentive to raise its rivals' costs. There is related literature investigating the patent holder's incentive to license its technology to its rivals such as Farrell and Gallini (1988), Rockett (1990), and Conner (1995) or investigating the vertically integrated input monopolists' (or the patent holder's) incentive to supply its input to its rivals such as Padilla and Wong-Ervin (2016) and Moresi and Schwartz (2017). This paper differs from those in that the patent holder allows its rivals to use its patent even without a license but keeps the option of patent litigation. That is, the patent holder has an option to grant a license to its rivals in the input market, called the component licensing, or to allow free access to its rivals and to give a license to the device manufacturers, called the end-product licensing. We show that in the component licensing model the patent holder has more incentive to raise its rivals' costs.

Keywords Patent Licensing, End-Product Licensing, Component Licensing

JEL Classification L14, L41

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1. INTRODUCTION

This paper analyses an industry which consists of vertically connected markets, i.e., the innovation or technology market, the input market, and the end-product market. We assume that there is a single innovator holding a patent which must be used in the input market. We also assume that the patent holder participates in the input market competing with other input producers. The key feature of this model is that any input manufacturer will be given an access to the technology either by obtaining a license (called "the component licensing") or by being granted a free access without a license[1]. In the latter case, the patent holder keeps the option to forbid its rivals from using its technology and thus the possibility of patent infringement litigation may cause input suppliers additional costs. Also in the latter case, the patent holder grants license to the end-product manufacturers only (called "the end-product licensing").

This paper investigates an incentive to raise its rivals' costs when a vertically integrated firm has a patent which is essential in upstream firms. Any firm in upstream market must use the patent to produce a key input to downstream firms. Downstream firms must use one input for each output. There may be two different sources of raising its rivals' costs in the input market. It can raise the possibility of patent infringement litigation in case free access to the technology is given without licensing. Or it can directly raise the royalty in case license is granted to input manufacturers. There is large literature investigating patent holder's incentive to license its technology to its rivals, e.g. Farrell and Gallini (1988), Rockett (1990) and Conner (1995). Unlike this paper, this literature investigates whether to deny or to grant a license to its potential competitors. If the request for licensing is denied, then the patent holder remains the only manufacturer. This paper differs from these papers in that the patent holder allows its rivals to use its patent and therefore makes the input market competitive.

Padilla and Wong-Ervin (2016) and Moresi and Schwartz (2017) are more closely related. For example, Padilla and Wong-Ervin (2016) analyses the industry practice of licensing on a portfolio basis at the end-user device level and whether a refusal to license at all levels of the production chain may constitute an antitrust violation, and shows that there is likely no foreclosure or exclusionary conduct or otherwise harm to competition. But their approach heavily depends on the fact that the patent holder should comply with FRAND[2] commitment.

[1]This policy is often called the "forbearance policy" in that the patent holder does not care to actively implement its right.

[2]A standard essential patent (or SEP) holders usually commit to license on fair, reasonable, and nondiscriminatory (known as FRAND) terms.

The patent holder's decision not to license at component level will not lead to anticompetitive foreclose only when the patent holder is bound by a FRAND assurance. In contrast, the patent holder in this paper does not have incentive to raise its rivals costs under certain conditions which are not related to FRAND conditions. Moresi and Schwartz (2017) also investigates the incentive to supply inputs to its downstream rivals. Whether the integrated firm gain or lose from expansion by its rival/customer depends on the relative size of competition effects and the supply effects. The mechanism of such effects are similar to that of market size effects and market stealing effects of this paper. In this paper the patent holder might raise its rivals' costs to have competitive advantage if they want, but the upstream competitor are allowed to access patent with or without a license and thus can participate in upstream market.

There are many examples which fit this market configuration. The mobile phone industry is a good example. There are three markets, a technology market, a chipset market, and a device market. There are firms developing mobile technology such as GSM, CDMA, LTE, and 5G, etc. including Qualcomm and Samsung and more. And there are manufactures producing chipsets which are intermediate goods to final products. Mediatek, Broadcom and Spreadtrum are such companies. Finally there are handset makers such as Samsung, LG and Apple. Qualcomm, the key patent holder, is a vertically integrated firm also manufacturing modem chipsets. However Qualcomm is not alone. Samsung also holds a portfolio of essential patents and produces modem chips and furthermore is a leading manufacturer of handset.

Recently competition agencies around the world are investigating whether patent holders' refusal to license at the component level violates any competition law. For example, Competition Commission of India (CCI) has brought two investigations against Ericsson, alleging that the company "seems to be acting contrary to the FRAND terms by imposing royalties linked with cost of product of user for its patents," i.e., for charging royalties based on the end-user device as opposed to a component part. The Korea Fair Trade Commission (KFTC) found Qualcomm's pratice of "licensing patents only at the device level" as opposed to the component level guilty of abusing its dominance. Other competition agencies, including in China and Japan, have recently issued revised final or draft guidelines that would seem to increase scrutiny of such conduct. This paper is related with such issues. The key difference is that those allegations are about whether the refusal to component level is acting contrary to the FRAND terms which the standard-essential patent(SEP)holder must abide by, but in this paper the patent holder does not have any FRAND obligation.

The remainder of the paper is organized as follows. In Section 2, we build a simple model to deal with two different licensing scenarios. We only compare the component licensing model with the end-product licensing model in that we don't analyse any licensing model in between. We assume that once the technology is licensed to input manufacturers, the patent holder cannot ask downstream end-product manufacturers any royalties. In this sense we assume the so-called "first sale patent exhaustion doctrine." In Section 3, we give main results and Section 4 provides concluding remarks.

2. MODEL

In order to analyse the economic effects of vertically integrated firm's strategic decision regarding patent licensing, we build a simple model that can analyse the effect arising from vertical integration of innovation market. We will use the following market structure. There are many downstream firms which sell end-products to consumers. And also there is an upstream oligopolistic market in which manufacturers sell necessary inputs to downstream firms. And finally there is a single firm which holds an essential patented technology required to produce the intermediate good. The patent holder is assumed to be vertically integrated into an upstream firm. We will call the vertically integrated firm "the patent and input provider" denoted by PI firm. The patent holder can license its patent either to upstream firms or to downstream firms, but not both. In other words, we assume that once the licensee in the upstream market has sold a good to downstream firms embodying the technology covered by patent rights, the right holder cannot license the patent to downstream firms[3].

The patent owner has an option to give a license either to input providers or to end-product manufacturers. We will consider two different licensing scenarios. In the first scenario, PI grants licenses to end-product makers and grants free access to input suppliers. We call this licensing practice the end-product licensing. In the second scenario, competing input manufactures are granted licenses. We call this licensing scheme the component licensing.

w_u denotes the royalty that PI charges to input suppliers. w_d denotes the royalty that PI charges to end-product (i.e., device) makers. q_I and q_c denote the input production quantities of PI and its competitors, respectively. It is assumed that n competitors [in the input market] are indistinguishable from one another. Input suppliers engage in Cournot competition. The inverse demand function of

[3]This is called the "First sale patent exhaustion doctrine." There are debates regarding how and when such a doctrine should be applied. But we will assume.

the input is given as $p(Q) = \alpha - q_I - nq_c$. End product makers purchase inputs at this price for their end-product production.

To simplify the model, it is assumed that one input corresponds only to one end-product, and vice versa. Therefore, the quantity of inputs sold is identical to the quantity of end products produced. This assumption is not unrealistic. Rather than analysing competition in the end product market in detail, we will assume that the end-product (or device) price is a monotone increasing function of cost, i.e., $p_{device} = f(p(Q))$ and $f' > 0$.

μ_I and μ_c denote marginal production costs of PI and its competitors, respectively. Input suppliers may incur additional costs as well as production costs due to various uncertainties such as, for example, those arising from the possibility of patent infringement litigation. It is assumed that PI, which owns patents, is able to control such uncertainties. Therefore, PI will be able to influence costs incurred by its competitors if it wishes to. The ability of PI to control uncertainties is denoted by θ_c. We will assume that the rivals' costs of PI including uncertainties are denoted by $\frac{\mu_c}{\theta_c}$.

Assumption 1. *If PI licenses its patent to input producers, then input manufacturers must pay the royalty rate which are proportional to the input price. Thus in case of component licensing,PI's royalty revenue can be expressed as* $n \times w_u \times (\alpha - q_I - nq_c)q_c$, *where* $w_u \in (0,1)$ *denotes the component royalty rate.*

Assumption 2. *If PI licenses its patent to end product producers, then they must pay the royalty rate which are proportional to the end price. Thus in case of end product licensing, PI's royalty revenue can be expressed as* $w_d \times p_{device}(q_I + nq_c)$ *which in turn can be expressed as* $w_d \times f(p(Q))(q_I + nq_c)$, *where* $w_d \in (0,1)$ *denotes the end-product royalty rate.*

The following is the objective function for PI as a patentee and input producer.

$$\pi^I = n[w_u \times (\alpha - q_I - nq_c)]q_c + [\alpha - q_I - nq_c - \mu_I]q_I \tag{1.1}$$

$$\pi^I = [\alpha - q_I - nq_c - \mu_I]q_I + w_d f(p(Q))(q_I + nq_c) \tag{1.2}$$

The equation (1.1) shows the objective function in case of the component licensing and the equation (1.2) shows that of the end-product licensing. The following is the similarly defined objective function for competing input suppliers in case of component licensing. Notice that in the end-product licensing, the

objective function can be defined with $w_u = 0$.

$$\pi^c = [(1-w_u)(\alpha - q_I - nq_c) - \frac{\mu_c}{\theta_c}]q_c \tag{2}$$

3. MAIN RESULTS

We will analyse effects of vertically integrated firm's strategic decision regarding patent licensing on its competing firms. Especially we will focus on whether PI has an incentive to foreclose its rival by not licensing essential patents. Recall that even without a license, rival firms are allowed to access its patents, but are open to the risk of patent infringement litigation. In order to analyse this, we will use two different licensing scenarios, the component licensing and the end-product licensing. We will investigate under which scenario the incentive to foreclose is higher. In the end-product licensing, the PI can raise its rivals' costs by controlling θ_c. On the other hand, the PI can directly raise its rivals' costs by charging higher w_u in component licensing.

3.1. END-PRODUCT LICENSING CASE

We first deal with a scenario under which PI grants licenses to end product makers and grants free access to input suppliers. In other words, $w_u = 0$ under this scenario. Let us analyse whether PI has an incentive to foreclose its competing input suppliers by raising their costs (or by lowering θ_c). As explained, PI is able to raise or lower its rivals' costs by influencing their θ_c. To analyse this influence, it is sufficient to confirm the sign of $\frac{\partial \pi^I}{\partial \theta_c}$. If the sign is positive, PI does not have an incentive to raise its rivals' costs. Applying the Envelope Theorem to Formula (1.1), $\frac{\partial \pi^I}{\partial \theta_c}$is expressed as the following:

$$\frac{\partial \pi^I}{\partial \theta_c} = -n(1+w_d f')\frac{\partial q_c}{\partial \theta_c}q_I - n^2 w_d f' \frac{\partial q_c}{\partial \theta_c}q_c + n w_d f(p(Q))\frac{\partial q_c}{\partial \theta_c} \tag{3}$$

$$= [n w_d f(p(Q)) - n(1+w_d f')q_I - n^2 w_d f' q_c]\frac{\partial q_c}{\partial \theta_c} \tag{4}$$

It is not difficult to show that $\frac{\partial q_c}{\partial \theta_c} \geq 0$. In other words, an increase in the marginal costs decreases outputs. Thus the sign of the RHS of the equation (4) coincides with the sign of $[n w_d f(p(Q)) - n(1+w_d f')q_d - n^2 w_d f' q_c]$. Therefore RHS of (4) is positive (+) if and only if

$$nw_d f(p(Q)) > n(1+w_d f')q_I + n^2 w_d f' q_c] \tag{5}$$
$$= n[q_I + w_d f'(q_I + nq_c)] \tag{6}$$
$$= n[q_I + w_d f'(\alpha - p(Q))] \tag{7}$$

The equation (7) can be expressed as follows;

$$f(p(Q)) + f' p(Q) > \frac{q_I}{w_d} + \alpha f' \tag{8}$$

The LHS of equation (8) can be also expressed as follows;

$$LHS = f(p(Q))[1 + \frac{df}{dp} \cdot \frac{p}{f}] = f(p(Q))[1+\varepsilon_p], where\ \varepsilon_p = \frac{df}{dp} \cdot \frac{p}{f}. \tag{9}$$

Notice that ε_p measures how sensitive the price of end-product is to the price of key input and thus can be interpreted as an input price elasticity of end-product price which is always positive. It is not difficult to see that if $f(p(Q))[1+\varepsilon_p] > \frac{q_d}{w_d} + \alpha f'$ holds or equivalently

$$w_d f(p(Q))[1+\varepsilon_p] - w_d \alpha f' > q_d \tag{10}$$

holds, then PI has no incentive to raise its rivals' costs.

When PI influences rivals' costs, there will occur two opposite effects. First, PI will be able to dominate the upstream market by raising its rivals' costs, and thereby increases its market share. We will call such effects market stealing effects. The RHS of equation (10) explains the market stealing effects. On the other hand, the resulting increase in the equilibrium input price will cause the end-product market to shrink. We will call such effects market size effects, which will in turn cause the royalty income of PI to decline. The LHS of equation (10) explains this. The first term in LHS explains the reduced royalty revenue due to shrink in the end product supply caused by the reduction in the input supply. And the second term explains changes in the royalty revenue caused by the increase in the end-product price. After all, whether PI will opt to raise its competitors' costs depends on the relative degree of each effect. The following Proposition 1 shows this.

Proposition 1. *If* $f(p(Q))[1+\varepsilon_p] > \frac{q_d}{w_d} + \alpha f'$ *holds or equivalently*

$$w_d f(p(Q))[1+\varepsilon_p] - w_d \alpha f' > q_d \ \ holds,$$

then

$$\frac{\partial \pi^I}{\partial \theta_c} \geq 0.$$

Under Proposition 1, where the market size effects dominate the market stealing effects, the more competitive input market is preferred by PI[4], and thus the less incentive PI has for raising its rivals' costs. Instead it has an incentive to lower its rivals' costs to spur more competition in the input market, which in turn lowers the end-product price and thus causes the end-product market to expand.

3.2. COMPONENT LICENSING CASE

Now, suppose that $w_d = 0$ and $w_u \neq 0$. This means that PI has adopted component level or input-level licensing instead of end product-level licensing.

PI's objective function is as follows;

$$\pi^I = n[w_u \times (\alpha - q_I - nq_c)]q_c + [\alpha - q_I - nq_c - \mu_d]q_I \tag{11}$$

The objective function for input suppliers is the same as Formula (2). Notice that under the component level licensing, input manufactures obtain licenses from PI and pay royalties under this scenario and therefore PI does not have the ability to influence θ_c. If PI wants to influence its rivals costs, then the only available option is to control the royalties, i.e., $w_u \neq 0$. As in subsection 3.1, we can analyse the incentive to raise its rivals costs by investigating the sign of $\frac{\partial \pi^d}{\partial w_u}$, which can be summarized as follows;

$$\frac{\partial \pi^I}{\partial w_u} = n[p(Q)q_c + w_u p(Q)\frac{\partial q_c}{\partial w_u} - (nw_u q_c + q_I)\frac{\partial q_c}{\partial w_u}] \tag{12}$$

Since it is not difficult to see $\frac{\partial q_c}{\partial w_u} < 0$, the following inequalities should hold.

$$\frac{\partial \pi^I}{\partial w_u} = n[p(Q)q_c + w_u p(Q)\frac{\partial q_c}{\partial w_u} - (nw_u q_c + q_I)\frac{\partial q_c}{\partial w_u}] \tag{13}$$

$$\geq n[p(Q)q_c + w_u p(Q)\frac{\partial q_c}{\partial w_u}] \tag{14}$$

$$= np(Q)q_c[1 + \frac{dq_c}{dw_u} \cdot \frac{w_u}{q_c}] \tag{15}$$

[4]In **?** the reason why the patent holder may decide to license her technology to its rival is similar to this paper in that the introduction of a competitor into the market may enhance demand.

Equation (15) clearly tells that the incentive to raise its rivals' costs depends on the royalty elasticity of competitor's output. The following Proposition 2 shows this.

Proposition 2. $\frac{\partial \pi^d}{\partial w_u} \geq 0$ *if* $\varepsilon_u \leq 1$, *where* $\varepsilon_u = -\frac{dq_c}{dw_u} \cdot \frac{w_u}{q_c}$.

Proposition 2 shows that PI has an incentive to increase royalties if the production quantity of its competitors is not elastic to the royalty level. If w_u is lower than the royalty level that ensures monopoly gains, it is highly likely that the production quantity of competitors of PI is not elastic to the royalty level. Furthermore if the patent owned by PI is essential, then input manufactures are not likely very sensitive to the royalty level set by the patent holder.

PI will be able to guarantee higher profits by increasing its market power in the input market if it can foreclose competitors or lower their production quantity. On the other hand, if the costs increase incurred by competitors of PI leads to an increase in input price and a reduction in sales volume, the patent holder's royalty income will decline as a consequence. In the meantime, as the demand for end-product depends on the quantity of inputs produced, PI revenue from input sales can be also be affected. Proposition 2 demonstrates that it is more advantageous for PI to enhance its market power in the component market if the production quantity of its competitors is not elastic in relation to the royalty level. That is to say, Proposition 2 shows that PI has an incentive to raise its rivals' costs even under a royalty.

4. CONCLUDING REMARKS

In the end-product licensing scenario, the vertically integrated patent holder has an incentive to raise its rivals' costs only when market stealing effects dominate market size effects (Propositon 1). That is, when PI raises its rivals' costs, it will cause rivals' input market price to rise which in turn increase market share of PI. Thus profits from input market will increase. On the other hand, more concentrated input market will cause the end-product market to shrink, which in turn lower royalty revenues. When market stealing effects dominate, therefore it is beneficial for the vertically integrated patent holder to raise its rivals' costs.

In the component licensing scenario, PI can raise its rivals' costs by increasing the royalty rate. Whether this strategic change in the royalty rate brings higher profits depends on the elasticity of input supply with regard to the royalty rate. Proposition 2 shows that if the production quantity of its competitors is not elastic in relation to the royalty level, then PI has an incentive to raise its

rivals costs by raising the royalty rate. Since the patent is assumed to be essential for input production, it is likely the case that the input supply is not sensitive to the royalty rate and thus the condition for Prospotion 2 is relatively easy to be satisfied compared with the condition for Proposition 1 to hold.

We only investigated under which licensing scenarios the incentive to raise its rivals' costs and thus to foreclose its competitors. However we have not discussed which licensing scenario brings more profits to the vertically integrated patent holder. A related literature is Layne-Farrar *et al.* (2014). Layne-Farrar *et al.* (2014) studies patent licensing in vertically disaggregated industries, where patent holders may license to upstream producers only, downstream producers only, or to both upstream and downstream producers, and shows that under ideal circumstances how royalty rates are split along the production chain has no real consequence for social welfare. This result is known as "royalty allocation neutrality." But their work is based on the assumption of vertically disintegrated patent holder and thus cannot be applied to our study. It will be an interesting extension of this study to figure out an equilibrium and to see what will be the optimal licensing scenario.

If it is in the best interest of the vertically integrated patent holder to choose the component licensing model, then the public regulator may need to monitor the level of royalty closely to protect market participants interests. On the other hand, when the end-product licensing is a standard licensing contract, then any attempt to switch to component licensing should be carefully evaluated with caution. We leave more detailed study on this issue for the future research.

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