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ORIGINAL ARTICLE

Enhancing vertical efficiency through horizontal licensing

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Abstract This paper examines the role of patent licensing in the age of outsourcing. When firms rely on outsourced inputs, a patent holder's decision to license has both competitive and supplier pricing effects. By issuing a license, the firm increases competition in the product market. At the same time, the need to make royalty payments "weakens" the firm's rival, making it more sensitive to supplier pricing. The supplier responds by softening pricing terms, and the firm benefits by siphoning some of these gains via the license fee. Not only can the licensor gain, but all other parties (the licensee, supplier, and consumers) can also benefit. This role of licensing presents additional considerations for regulators shaping patent laws.

Keywords Licensing · Outsourcing · Patents

JEL Classification D45 · L4 · L12 · O34

1. Introduction

In recent times, an increasing number of firms have opted to grant competitors access to valued assets by licensing their patents. It is estimated that licensing revenues now top $100 billion annually in the US (Kline, 2003). At the same time, a trend towards outsourcing has heightened firms' reliance on suppliers. The importance of suppliers is underscored by the fact that "more than 90 percent of companies say that outsourcing is an important part of their overall business strategy" (Corbett, 2004, 3).

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This paper considers the impact of outsourcing on the decision to license, and the concomitant effects on other players in the marketplace. The results suggest that the joint increases in licensing and outsourcing may be more related than one might conjecture. In particular, we show that a firm wishing to procure better pricing from a supplier may choose to license its core technology to a competitor. Licensing removes the firm's monopoly position, but the inclusion of royalty fees also means the competitor is more sensitive to supplier pricing than the firm. As a result, the supplier is compelled to lower prices for the competitor's sake, the benefit of which is partially extracted by the patent holder.

The patent holder's decision to weaken its inherent competitive edge has ramifications for other market participants. In particular, the reduction in double marginalization in the intermediate good market brought about by lower supplier prices opens the door for Pareto improvements. Though the supplier is forced to charge lower prices, it also benefits from increased demand on two dimensions. First, its lowered pricing elicits a favorable order from the rival. Second, the increased competition between the firm and the rival in the final product market increases the total demand for the good it supplies. The net effect is that the supplier gains from licensing. Of course, increased competition under licensing also implies that the consumers reap benefits in terms of lowered product prices. Finally, by receiving rights (but no obligation) to use a patent, the rival too benefits.

Such Pareto gains that stem from licensing suggest an additional consideration in the recurring debate over regulation of patents. In some circumstances, the downside of patents is not as severe as often suggested. A patent holder who is granted monopoly powers through patent protection may find it useful to voluntarily give up some of this power. Thus, an intermediate point between exclusive rights and public domain which all parties find amenable may naturally arise even under the strongest patent laws.[1]

Welfare enhancement may also be a feature of other arrangements that straddle the line between cooperation and competition. A case in point is a research joint venture (RSJ) which involves cooperation among firms in technology development who may later compete in the sale of products. RSJs are often justified on the grounds of exploiting synergies in research and development while eluding the ire of antitrust regulators in the final product market. The intuition gleaned herein suggests that such ventures may be useful even if complete integration of the firms in the venture is not subject to antitrust regulation. When venture participants rely heavily on outsourcing, the competition which comes subsequent to joint technology development may be welcome because it discourages excessive pricing by suppliers. In effect, an inherent self-regulation aspect of such ventures may help take some of the burden off regulators.

Our analysis also revisits the question of fees versus royalties in structuring a licensing contract.[2] In the setting, royalties are a necessary element for a license to be useful. However, this does not mean fixed fees are useless: the firm's preferred route is a contract with both a fixed fee and royalty rate. Such an arrangement has the added benefit of being preferred by the supplier and product consumers. This view is consistent with observed practices, where royalties have been documented in 82% of licensing contracts, over half of which also included a fixed fee (Rostoker, 1984).

There are, of course, other explanations for a firm to license its patents. For one, a patent holder may not have the wherewithal to produce a final good (or at least is less efficient

[1] The desirability of such an intermediate scenario has been the impetus for regulators pushing patent laws which prescribe compulsory licensing requirements (e.g., Aoki & Small, 2004; Tandon, 1982).

[2] The fees versus royalties debate has yet to converge to a consensus (e.g., Kamien & Tauman, 1986; Wang, 1998).

than its rival in doing so) and decides to rely on licenses for a product to come to fruition. Similarly, for firms competing in differentiated markets, licensing a patent to a competitor may, in essence, be a means of reaching different consumers (e.g., Fauli-Oller & Sadonis, 2003). For firms who patent to direct competitors, licensing may be a means of promoting an "industry standard," discouraging innovation by competitors (Tirole, 2003), or driving out other entrants (Gallini, 1984). In this paper, licenses are optimal despite the absence of such considerations. It is the (indirect) effect on upstream suppliers brought by a horizontal license that proves critical.

The source of license benefits in this paper is that the ensuing competition naturally puts the firms in a weaker position, thereby encouraging better supplier terms. Effectively, licensing serves as a means of self-sabotage (Sappington & Weisman, 2005). However, in contrast to Sappington and Weisman, self-sabotage is undertaken not to soften horizontal interactions (competition actually increases) but rather to achieve more efficient vertical interactions.

2. The licensing decision

2.1. Setup

A firm owns a patent for a technology that gives it exclusive (monopoly) rights to produce a particular product. Consumer demand for the product is represented by a linear, downward sloping, (inverse) demand function $P = a - bQ, a > 0, b > 0$, where P and Q are the price and the quantity of the product, respectively.

To make the product, the firm requires an intermediate good (input) that is provided by a sole supplier. For simplicity, assume: (i) one unit of the final product requires one unit of the intermediate good, and (ii) the supplier produces the good at a constant unit (marginal) cost $c, c < a$. The firm's cost of converting the good to the final product is normalized to zero.

The firm has the option to license its patented technology to another party which then becomes a Cournot rival in the final product market. The licensing arrangement stipulates a royalty fee: for each unit the rival makes, it pays the firm r.

Like the firm, the rival too relies on the supplier for the intermediate good. In dealing with buyer $i, i = F$ (firm) or R (rival), the supplier sets its per unit price t_i, and buyer i responds by purchasing q_i units.

In this setup, we ask two questions. First, will the firm ever prefer to give up its monopoly power by issuing a license and thus welcoming competition? Second, what are the efficiency implications of such a technology transfer assuming it is willingly undertaken?

2.2. The firm as a monopolist: the outcome under no licensing

By not issuing a license, the firm prevents any encroachment of its customer base. In the absence of the rival, the outcome in the firm-supplier game is straightforward to determine using backward induction. Given a supplier price t_F, the firm chooses q_F to maximize its monopoly profit in the product market. That is, the firm solves:

$$\underset{q_F}{\text{Max}}[a - bq_F]q_F - t_F q_F. \tag{1}$$

The first-order condition of (1) with respect to q_F yields q_F^N, the optimal supply of the product in the no-license case:[3]

$$q_F^N = \frac{a - t_F}{2b}. \tag{2}$$

In effect, (2) serves as the induced demand function for the supplier. Hence, the supplier chooses t_F to maximize its profit, solving:

$$\underset{t_F}{\text{Max}}[t_F - c]q_F^N. \tag{3}$$

The first-order condition of (3) with respect to t_F yields t_F^N, the optimal price set by the supplier for the intermediate good in the no-license case, and substituting t_F^N in (2) gives q_F^N:

$$t_F^N = \frac{a + c}{2} \quad \text{and} \quad q_F^N = \frac{a - c}{4b}. \tag{4}$$

Not surprisingly, the supplier sets price above marginal cost, and the firm responds by procuring less than it would have had the supplier charged c. This is the familiar double marginalization problem—total supply chain profits are lower than if the supplier and the firm were vertically integrated. Substituting (4) into (1) and (3), the firm and supplier profits in the no-license setup, denoted Π_F^N and Π_S^N, respectively, equal:

$$\Pi_F^N = \frac{(a - c)^2}{16b} \quad \text{and} \quad \Pi_S^N = \frac{(a - c)^2}{8b}. \tag{5}$$

The other interested parties in this scenario are the consumers. Consumer surplus in the no-license case, CS^N, equals:

$$CS^N = \int_0^{q_F^N} b(q_F^N - q)\mathrm{d}q = (1/2)b(q_F^N)^2 = \frac{(a - c)^2}{32b}. \tag{6}$$

2.3. The firm with a competing rival: the outcome under licensing

By issuing the license, the firm creates a rival in the final product market. While one may be tempted to conjecture that this move can only hurt the firm, such a conclusion turns out to be hasty. The reason is that the issuance of a license, in conjunction with a judiciously chosen royalty fee, can influence the supplier's behavior. Roughly stated, the firm chooses to create a weak rival whose "weakness" naturally elicits better terms (pricing closer to marginal cost) from the supplier. The royalty fee then transfers some of these gains back to the licensing firm.

The above description may create the impression that the firm stands to benefit from licensing only if the supplier loses. As it turns out, this too is not the case. The reason is that there is an offsetting factor that benefits the supplier: licensing also creates competition between the firm and the rival. Such competition yields total demand for the supplier's product that is higher than in the no-license case. While increased competition is surely an unappealing feature of licensing to the firm, it is a boon to the supplier.

The two-fold effect of licensing, that it increases total demand in the final product market and reduces the problem of double marginalization in the intermediate good market, allows for an increase in productive efficiency and provides an opportunity for Pareto gains. If firms could produce the intermediate good internally (so double marginalization is moot), a shift

[3] Throughout the paper, the first-order approach is valid since second-order conditions are always met and ensuing prices and quantities are positive.

from a monopoly to a duopoly leads to increased production (and reduced prices) wherein consumers gain but total firm profit is lower. Thus, the source for Pareto improvements in our setting is that the external supplier can be persuaded to be less aggressive in price mark-ups when confronting a weak buyer. Conveniently, the firm's optimal royalty rate that creates the weak buyer achieves gains not just for the firm but also ensures that the rival, the supplier, and the consumers all benefit from the issuance of the license. To confirm this, we examine the three party game—the strategic interactions between the supplier, firm, and rival—under licensing.

Again, we work backwards in the game, starting with the duopoly outcome given a royalty rate r and supplier prices t_F and t_R. With rival production q_R, the firm chooses q_F to maximize its profit in the product market. That is, the firm's competitive response function solves:

$$\underset{q_F}{\text{Max}}[a - b(q_F + q_R)]q_F - t_F q_F + r q_R. \tag{7}$$

The first-order condition of (7) with respect to q_F yields the firm's supply of the product for a given level of rival supply:

$$q_F = \frac{a - t_F}{2b} - \frac{q_R}{2}. \tag{8}$$

In a similar fashion, the rival's response function is obtained by solving:

$$\underset{q_R}{\text{Max}}[a - b(q_F + q_R)]q_R - t_R q_R - r q_R. \tag{9}$$

The first-order condition of (9) with respect to q_R yields the rival's supply of the product for a given level of firm supply:

$$q_R = \frac{a - t_R - r}{2b} - \frac{q_F}{2}. \tag{10}$$

In (10), the rival effectively internalizes the royalty rate as an added cost of production. Thus, higher royalty rates serve to cut rival production. Of course, a high enough royalty rate will itself drive out competition; but, the firm may have reason not to go to such an extreme. The intersection of (8) and (10) yields the equilibrium quantities in the licensing case, q_F^L and q_R^L, given r, t_F, and t_R:

$$q_F^L = \frac{a - 2t_F + t_R + r}{3b} \quad \text{and} \quad q_R^L = \frac{a - 2(t_R + r) + t_F}{3b}. \tag{11}$$

Naturally, each firm's quantity is decreasing in the price it pays for the intermediate good; for the rival, part of this price is r. This effect also reverberates on the production of the other, in that a higher price for the rival encourages the firm to increase its production, and vice versa. Given this competitive outcome, the supplier sets prices accordingly, solving:

$$\underset{t_F, t_R}{\text{Max}}[t_F - c]q_F^L + [t_R - c]q_R^L. \tag{12}$$

The first-order conditions of (12) with respect to t_F and t_R yield the supplier's prices with licensing, t_F^L and t_R^L:

$$t_F^L = \frac{a + c}{2} \quad \text{and} \quad t_R^L = \frac{a + c - r}{2}. \tag{13}$$

While the price offered to the firm is as before, the rival is able to procure a lower price due to the effect of r on its demand.[4] Recognizing that the rival also has to make royalty payments to the firm, the supplier is induced to lower prices for the rival so as to keep up demand. Since the firm reaps some of the ensuing benefit to the rival (via r), it can indirectly profit from such softer pricing terms. Given the pricing arrangement in (13), using (11), the production quantities of the two firms in equilibrium are:

$$q_F^L = \frac{a - c + r}{6b} \quad \text{and} \quad q_R^L = \frac{a - c - 2r}{6b}. \tag{14}$$

Note, if $r = 0$, (14) yields the familiar duopoly quantities. On the other hand, if $r = (a - c)/2$, then (14) is the monopoly solution—q_F^L is equal to q_F^N in (4), and $q_R^L = 0$. As we next see, the firm chooses a middle-of-the-road approach. Substituting (13) and (14) in (7) provides the firm's profit in case of licensing, Π_F^L:

$$\Pi_F^L = \frac{(a - c)^2}{36b} + \frac{r(8a - 8c - 11r)}{36b}. \tag{15}$$

The firm's chosen royalty rate maximizes (15), or

$$r = \frac{4(a - c)}{11}. \tag{16}$$

Using the optimal r in (14) yields:

$$q_F^L = \frac{5(a - c)}{22b} \quad \text{and} \quad q_R^L = \frac{a - c}{22b}. \tag{17}$$

Substituting (17) into (7) and (9), and using supplier prices from (13) with r as in (16) confirms firm and rival profits under patent licensing:

$$\Pi_F^L = \frac{3(a - c)^2}{44b} \quad \text{and} \quad \Pi_R^L = \frac{(a - c)^2}{484b}. \tag{18}$$

The first proposition then follows by comparing firm profit in (5) with that in (18).

Proposition 1 *The firm strictly benefits from patent licensing.*

As alluded to earlier, the key to Proposition 1 is the firm's ability to indirectly secure better pricing terms from the supplier—it does so by creating a weak rival for the supplier to deal with, and then siphoning some of the gains. If the rival is too strong (i.e., r is small), it does not elicit a generous supplier response. If the rival is too weak (i.e., r is large), it procures little. The firm chooses r in (16) to avoid these extremes. Roughly stated, judicious choice of r allows the firm to exert a degree of indirect monopsony power in its relationship with the supplier. As an aside, we note that similar benefits can arise if the supplier is forced to charge the same price to both firms. In such a case, the benefit of r is similar but more straightforward—by creating a weak buyer, the firm forces the supplier to offer the same moderated pricing terms to both parties (the supplier's price will be between the two prices derived in (13)).

The fact that the rival too benefits from procuring the license is as expected since it now accesses a previously unreachable market. It is more of a surprise that satisfaction with the

[4] The fact that licensing has no effect on the price offered to the firm is due to the linear nature of the setting. In other circumstances, interactions may arise in which the supplier raises the firm's price so as to extract some of the royalty payments gleaned from the rival. Such a scenario evolves, for example, if the supplier's cost function is quadratic.

licensing arrangement also spills over to the supplier. In particular, substituting (13) and (17) into (12) with $r = \frac{4(a-c)}{11}$, supplier profit in the licensing case is:

$$\Pi_S^L = \frac{31(a-c)^2}{242b}. \tag{19}$$

Comparing (5) and (19) confirms the supplier's windfall from licensing. Though licensing is used to solicit better terms from a supplier, the fact that it also entails more competition means that the enhanced efficiency is naturally shared. To finish the comparison of interested parties, consider the consumers. Consumer surplus in the licensing case, CS^L, equals:

$$CS^L = \int_0^{q_F^L + q_R^L} b\left(q_F^L + q_R^L - q\right)\mathrm{d}q = (1/2)b\left[q_F^L + q_R^L\right]^2 = \frac{9(a-c)^2}{242b}. \tag{20}$$

Comparing (6) and (20), coupled with the above comparisons for the supplier and rival confirms the following proposition.

Proposition 2 *The firm's decision to license strictly benefits its rival, the supplier, and consumers.*

The Pareto gains from licensing in the presence of supply chain double marginalization suggests an added consideration in the debate over patents. The traditional view is that regulators offer patents reluctantly to encourage innovation and protect property rights. The hesitation is due to the downside of granting monopoly power. In this setting, however, a firm who is granted monopoly power through a patent is not so ruthless. The patent holder chooses to share its invention with competitors, leading to gains for all parties.

2.4. Licensing terms: royalty versus fixed fee

In the preceding analysis, we considered the benefits of licensing under an arrangement that specified only a royalty rate. In practice, licensing arrangements can also involve fixed fees. In this section, we consider fixed fee contracts to see if and how this affects the firm's desire to license. In the case of a fixed fee only contract, the firm and the rival compete on an equal footing since the fixed license fee, denoted F, is invariant to the parties' chosen production levels; in effect, F is a sunk cost in the duopoly game. Thus, the production levels are as in (14) with $r = 0$. Clearly, the most the firm can charge as fixed fee is the amount the rival stands to gain from producing the product. Plugging prices from (13) and production levels from (14) into (9), and setting $r = 0$ yields the fixed fee set by the firm:

$$F = \frac{(a-c)^2}{36b}. \tag{21}$$

Firm profit in the case of a fixed-fee license is F in (21) plus Π_F^L in (15) with $r = 0$, or

$$\frac{(a-c)^2}{18b}. \tag{22}$$

The profit in (22) is less than that in (5). Hence, not only does the firm prefer a royalty-based contract to a fixed fee contract, but it also prefers no license at all to a fixed fee license. With a fixed fee, the firm and rival are equally strong, and the supplier charges $(a+c)/2$ to each. In this case, there are no double marginalization gains to be had. Moreover, the game between the firm and the supplier is one of pure duopoly. Since total duopoly profits are less than monopoly profit (competition is the only real effect of the license), the firm prefers retaining its patent rights.

This is, of course, not to say that a fixed fee is not valuable when used along with royalty payments. In such a case, pricing and production decisions are again as in (13) and (14), respectively, but the firm's optimal choice of r is different. Since F can be set to extract all of the rival's profit, the firm's preferred r is one that maximizes the sum of its own profit and the rival's profit, or (7) plus (9). Substituting (13) and (14) in these expressions implies the firm chooses r to maximize:

$$\frac{(a-c)^2}{18b} + \frac{r(4a-4c-7r)}{36b}. \tag{23}$$

Solving the first order condition of (23) with respect to r yields:

$$r = \frac{2(a-c)}{7}. \tag{24}$$

The r in (24) is less than that in (16) when a fixed fee was unavailable. The reason is straightforward. Without a fixed fee, a high r value was used to create a weak rival as well as transfer wealth from the rival to the firm. The latter role can be served by a fixed fee. This decreased pressure on r results in a decline in the optimal r value.

Plugging the r from (24) in (14) yields:

$$q_F^L = \frac{3(a-c)}{14b} \quad \text{and} \quad q_R^L = \frac{a-c}{14b}. \tag{25}$$

The total production in (25) is greater than that in (17), indicative of the fact that the rival is not as weak as before and, hence, the competition is more severe (the price of the final product is lower).

Substituting (24) into (23) yields the firm's profit since F is chosen such that the rival's profit is reduced to 0. In particular, the optimal F value and the firm profit are:

$$F = \frac{(a-c)^2}{196b} \quad \text{and} \quad \Pi_F^L = \frac{(a-c)^2}{14b}. \tag{26}$$

The availability of the extra fixed fee instrument to extract rival profit implies firm profit in (26) is greater than in (18). In fact, the sum of firm and rival profits is higher as well, consistent with the idea that the firm's choice of r is not as aggressive when F is at its disposal.

To make welfare comparisons, plug (13) and (25) into (12) and the consumer surplus expression with $r = 2(a-c)/7$. This yields supplier profit and consumer surplus of:

$$\Pi_S^L = \frac{13(a-c)^2}{98b} \quad \text{and} \quad CS^L = \frac{2(a-c)^2}{49b}. \tag{27}$$

Comparing (27) to (19) and (20), the supplier and consumers are also better off with a license specifying a fixed fee in conjunction with a royalty rate. These results are summarized in the following proposition.

Proposition 3 (i) *The firm prefers not to license when licensing entails only a fixed fee.* (ii) *Augmenting royalty payments with a fixed fee is preferred by the firm. Such an arrangement also benefits the supplier and consumers.*

Part (i) of the proposition highlights the unique role played by licensing in this setup. Other drivers of licensing discussed in the literature, such as exploiting the efficiency advantages of another (rival) firm, point to benefits from selling rights for a fixed fee. In this case, however, not establishing royalty payments renders the license useless, as it prevents the firm from using the rival as a vehicle for obtaining lower supplier prices. As stressed in part (ii) of the

Proposition, however, a fixed fee is valuable when used in conjunction with royalties. While it is not surprising that two instruments (fixed fee and royalties) yields higher firm profit than any one instrument, the fact that benefits from the multi-instrument approach are also gleaned by the supplier and consumers gives further credence to the welfare-enhancing role of licenses.

Finally, a word about our reliance on linear demand and cost structures. While this approach allows presentation of the salient points with a minimum of technical obfuscation, it does raise the issue of generality. Fortunately, linearity is not critical to the results. For example, conducting much the same analysis as done previously in the paper, it is easy to verify that all propositions continue to hold if the cost function is quadratic. Of course, this is not to say that the results hold universally for all demand and cost formulations.[5]

3. Conclusion

The prevalence of patent licenses issued to potential competitors is a curious phenomenon. Detractors find it illogical that firms develop patents for exclusive use, but subsequently hand over those rights to rivals. This paper provides one explanation. When a firm (and its potential competitor) rely heavily on suppliers for key inputs, licensing can help procure better supplier pricing. By generating competition, licenses serve to weaken the firms' willingness to pay for inputs, thereby convincing suppliers to lower prices. The lower prices and subsequent increase in demand serve to reduce problems of double marginalization along the supply chain. As a result, licenses can lead to Pareto improvements.

In the setting, a supplier exerts monopoly power thereby introducing imperfections in the input market. It is such imperfections which give rise to licensing. Thus, if the input market were perfectly competitive, marginal-cost pricing would rule out any need for licensing. Alternatively, if the supplier could employ a two-part tariff, supplier price cutting would be moot, as the supplier would rely on marginal-cost pricing and use a fixed fee to extract any firm surplus (e.g., Tirole, 1993). There may also be other noteworthy influences on the supply market. For example, circumstances may allow alternative inputs to be used (as in a variable-proportions technology). In such a case, the mere presence of an alternative input, even if it is more costly, may help rein in supplier pricing. This, in turn, undercuts the benefits of licensing. In short, the appeal of licensing identified here is most apt to apply in circumstances where a firm is otherwise stymied in limiting supplier prices.

In closing, we note that the two features which undergird the paper's results each appear to be growing in economic importance. Not only have firms relied more heavily on external suppliers to achieve their strategic objectives in recent years (Corbett, 2004), but they have also greatly expanded their use of licensing and other technology-sharing arrangements (Kline, 2003; Lerner & Tirole, 2005). The results presented here suggest that the arrival of these trends in tandem may not be a coincidence. As these trends further evolve, rigorous empirical testing may help sort out to what extent the nature of buyer–supplier relationships has influenced patterns of sharing among competitors, and vice versa.

[5] In fact, the firm may sometimes even prefer not to issue a license (in which case, welfare improvements are moot). This is indeed the case if $P = a - b\text{Ln}(Q)$. Under this demand function, from the firm's perspective, the marginal cost associated with introducing competition through licensing overwhelms the benefit of undercutting supplier price.

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