Licensing and bundling

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Abstract

A common problem in licensing contracts is that contractual language does not necessarily guarantee that the license will effectively be exclusive. The practical difficulty is that the licensor may be able to invent around this restriction. We show that commodity bundling may provide a mechanism for the innovating firm to credibly commit to act less aggressively after licensing a product innovation. As a result, bundling and licensing may be complementary strategies. Even if the innovating firm does not have the incentive either to license or to bundle, it may still have the incentive to follow a licensing plus bundling strategy. We identify a second remedy for the licensor’s commitment problem: a royalty. We show that, under certain conditions, a royalty may be used as a commitment device enabling the licensor to credibly — and costlessly — establish exclusivity.

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1. Introduction

The theoretical literature on technology transfer through licensing has identified several incentives to license process innovations or new products to competitors. In general, if side payments are possible, licensing is beneficial whenever it raises industry profits. Licensing may increase industry profits through the replacement of inefficient production techniques (e.g., McGee, 1966; Salant, 1984; Gallini and Winter, 1985; Katz and Shapiro, 1985), by increasing industry demand (e.g., Shepard, 1987; Farrell and Gallini, 1988), by facilitating collusion (e.g., Shapiro, 1985; Lin, 1996), by eliminating R&D expenditures that are wasteful from the industry’s point of view (e.g., Gallini, 1984; Gallini and Winter, 1985), or by deterring entry of a stronger competitor once the patent expires, prolonging the innovating firm’s dominant position in the industry (e.g., Rockett, 1990).

While the existing literature focuses on process innovations or on new products, firms often develop complementary products or services or new components that increase the quality of a given product. A new safety device or climate control system for automobiles, a new accessory for cameras, a new maintenance service, a better post-sale service or a new home-delivery service constitute examples of such quality-improving innovations. These innovations may be employed in several ways. First, the innovating firm may follow an independent pricing strategy, selling the complementary product or service or the new component separately to consumers. Second, the firm may follow a bundling strategy, i.e., it may incorporate the innovation in its own product, in an attempt to create a (vertical) differentiation advantage in the product market. In addition to an independent pricing or a bundling strategy, the innovating firm may share the technology with competitors through licensing agreements.

The recent transformations at General Electric (GE) illustrate the importance of quality-improving innovations. As reported by Business Week (Oct. 28, 1996, Cover Story, pp. 42–50), Jack Welch, GE’s Chairman and CEO, has launched two company-wide initiatives aimed at increasing the company’s growth. The first is a drive to boost quality. The second represents an effort to capitalize on the company’s most valuable assets. Jack Welch realized that for the company to fully appropriate the potential rents associated with its core industrial strengths in businesses as far afield as health care, aircraft engines, power generation and utilities, GE should consider alternative uses for its complementary products or services or new components. As a result, for instance, GE Medical Systems signed exclusive multi-year service deals with big hospital chains which involve servicing rival manufacturers’ medical equipment; and GE Power Systems is managing power plants for independent power producers. According to Business Week, GE’s

\footnote{Commodity bundling is generally defined as the practice of selling two or more products or services in a single package, as opposed to independent pricing.}
efforts are ‘being closely watched . . . as a pattern for the refashioning of an industrial company in a postindustrial economy’ (Oct. 28, 1996, pp. 43–44). 2

In this paper, we study firms’ incentives to license quality-improving innovations comparing independent pricing, bundling, licensing, and licensing plus bundling. Clearly, when the innovating firm has a competitive disadvantage in the production of the basic (or original) product, it may have the incentive to license the innovation exclusively to the most efficient producer. 3 An exclusive license is one in which the right to use the innovation is granted to the licensee to the exclusion of all the other firms, including the innovating firm. Such a licensing contract may allow the licensee to monopolize the production of the basic product and the innovation, increasing industry profits by inducing coordinated pricing of both products.

A common problem with this arrangement is that ‘impacted information [ . . .] limits the ability of a producer who owns the innovation to forego use of the innovation by selling the exclusive rights to use it to the other producer’ (Katz and Shapiro, 1985, p. 508; emphasis original). In fact, contractual language does not necessarily guarantee that the license will effectively be exclusive. The practical difficulty is that the licensor may be able to invent around this restriction. After all, it is the licensor who came up with the innovation and who wrote the patent, and hence the licensor is in a very good position to invent around it. If the innovating firm cannot credibly commit not to use the licensed technology, then, effectively, the license will be nonexclusive.

We show that, when exclusive licensing is not possible, licensing and bundling may be complementary strategies. Even if the innovating firm does not have the incentive either to license or to bundle, it may still have the incentive to follow a licensing plus bundling strategy. Bundling provides a mechanism for the innovating firm to credibly commit to compete less aggressively after licensing the quality-improving innovation to the most efficient competitor. By choosing a bundling strategy, the innovating firm accepts a disadvantage in the production of the enhanced product (composed of one unit of the basic product and one unit of the innovation), credibly committing to compete less aggressively after licensing

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2 Complementary services, in particular, are becoming more and more preeminent in many industries, such as the automobile industry, the airline industry, the financial services industry and the power industry (to name just a few). As Quinn et al. (1990), point out, ‘[m]ore and more companies are beginning to look like those in the personal computer industry, where producing the actual “box” is a low-margin activity, and software and service-support activities create most of a product’s value to customers’ (1990, p. 59).

3 Alternatively, one can think of an arrangement where the most efficient producer licenses the technology underlying the production of the basic product to the innovator. However, to focus on firms’ incentives to license quality-improving innovations, we assume that the production of the basic product involves a complex set of highly routinized activities, with a strong tacit dimension, and, therefore, licensing of the underlying technology is very problematic.
the innovation. Nonexclusive licensing may then result in higher industry profits by inducing coordinated pricing of the basic product and the innovation.

We identify another remedy to the commitment problem faced by the innovating firm when licensing the innovation: a royalty (per unit of output produced with the innovation). In general, a royalty influences the firms’ decisions in two ways. First, it reduces the licensor’s incentives to use the licensed technology. This is because using the technology cannibalizes royalty revenues. Second, the royalty changes the marginal cost of production on which the licensee bases its decisions. Interestingly, we show that under certain conditions a royalty may be used as a commitment device enabling the licensor to credibly — and costlessly — establish exclusivity. We specify conditions under which a royalty allows the licensor to credibly commit not to use the licensed technology without introducing any distortion in the equilibrium prices.

This paper is also related to the literature on commodity bundling. Bundling has been extensively studied as a price discrimination device. It has been shown that when price discrimination is not possible, bundling can be used to obtain at least some of the profits yielded by first-degree price discrimination (e.g., Stigler, 1963; Adams and Yellen, 1976; Schmalensee, 1982, 1984; Dansby and Conrad, 1984; Lewbel, 1985; McAfee et al., 1989). In addition, several authors provide formal models that justify what has been known as the ‘leverage hypothesis’ of bundling: the idea that a firm with monopoly power in one market may use bundling to profitably extend its monopoly power to a second market. Whinston (1990) shows that bundling may lead to the monopolization of a previously oligopolistic market by lowering competitors’ profits below the level that would justify continued operation. Carbajo et al. (1990) and Seidmann (1991) show that in the presence of imperfect competition, bundling may be profitable because it induces rivals to compete less aggressively.

We also identify a strategic motivation for bundling. Bundling may provide a means for the innovating firm to credibly commit to act less aggressively after licensing a product innovation. The mechanism underlying this commitment is simple. Although under licensing (without bundling) the licensor and the licensee are equally efficient in the production of the innovation, and therefore compete aggressively in that product, under bundling plus licensing the licensor accepts an inefficiency in the production of the enhanced product. This mitigates competition.

The remainder of this paper is organized as follows. In Section 2, we introduce the model. In Section 3, we compare independent pricing, bundling, and licensing under the assumption that exclusive licensing is not possible and that firms are restricted to fixed-fee licensing contracts. In Section 4, we introduce licensing plus bundling. In Section 5, we extend the model by considering situations where

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4 Other typical explanations for bundling include economies of scope, risk sharing, protection of goodwill, evasion of price controls, and monitoring a cartel (e.g., Director and Levi, 1956; Cummings and Ruhter, 1979).
exclusive licensing is possible and where the licensing contract may include a royalty. Section 6 concludes.

2. The model

We model an industry with two firms, indexed by \( j = 1,2 \), able to produce a homogeneous product \( x_B \) (the basic product), at a constant marginal cost \( c_j \), where \( c_1 < c_2 \). In addition, firm 2, the less efficient firm in the production of \( x_B \), developed an innovation \( y \) which, when used together with product \( x_B \), results in an enhanced (vertically differentiated) product \( x_E \). Without loss of generality, assume that the marginal cost of production of the innovation, \( c_y \), equals zero. Let \( p_k \) refer to the price charged for product \( k \) by firm \( j \).

Define \( D_B(p_B, p_E) \) as the demand for \( x_B \), where \( p_B \) is the price of \( x_B \) and \( p_E \) is the price of \( x_E \), and \( D_E(p_B, p_E) \) as the demand for \( x_E \). \( D_B(p_B, p_E) \) is assumed to be strictly positive for all non-negative prices. \( D_B(p_B, p_E) \) is assumed to be strictly positive for any pair of prices \( (p_B, p_E) \) such that \( p_B < p_E \), and equal to zero for any pair of prices such that \( p_B \geq p_E \). This reflects vertical differentiation: if both products are offered at the same price, consumers strictly prefer to buy product \( x_E \) to product \( x_B \). \( D_B \) and \( D_E \) are differentiable in both arguments for any pair of prices \( (p_B, p_E) \) such that \( p_B < p_E \). Furthermore, for any pair of prices such that \( p_B < p_E \), \( D_i = \frac{\partial D_i}{\partial p_i} < 0 \), \( D_{im} = \frac{\partial D_i}{\partial p_m} > 0 \) and \( |D_{ii}| \geq |D_{im}| \), for \( i,m \in \{B,E\} \) and \( i \neq m \).

We study the choice between independent pricing, bundling, licensing and licensing plus bundling. It is assumed that the innovating firm is able to precommit to bundling before pricing decisions are made. This is an important assumption. In this model, as in Carbajo et al. (1990), Whinston (1990), and Seidmann (1991), absent precommitment bundling is not a useful strategy — any equilibrium outcome will be equivalent to one where only independent pricing is allowed. As Whinston puts it: ‘One of the primary ways in which this [precommitment] can be accomplished is through product design and the setting of production processes, both of which may involve significant sunk costs. By bundling components of its system together or by making interfaces between the separately sold components incompatible with their rivals’ components, firms can precommit to their marketing strategy’ (1990, p. 839).

It is common practice to distinguish pure and mixed bundling. Under pure bundling, the innovating firm offers only the bundle \( x_{E2} \) composed of one unit of \( x_B \) and one unit of \( y \). Under mixed bundling, the innovating firm sells the bundle,
and the basic product, $x$, we restrict our attention to mixed bundling. As will be made clear later, this restriction considerably simplifies the model, without affecting the main results.

For most of the analysis, we assume that exclusive licensing is not possible and that firms are restricted to fixed-fee licensing contracts. As already mentioned, a common problem in licensing contracts is that the licensor may be able to invent around the licensed innovation. If the innovating firm is not able to credibly commit not to use the licensed technology, then, effectively, the license will be nonexclusive. In such cases, the question is whether the innovating firm will reserve use of the innovation for itself or share it with the other firm. A contract specifying a royalty may not be feasible because it may be difficult to monitor the licensee’s output, as it is necessary to enforce a contract specifying a royalty. As Katz and Shapiro point out, “[t]his may be so for purely informational reasons, or because, once he has the licensed technology, the rival can imitate the innovation and produce output with the imitation, thereby avoiding per-unit charges” (1985, p. 508). Situations where exclusive licensing is possible and where the licensing contract may include a royalty are considered in Section 5.

We consider a two-stage game. In the first stage, the innovating firm decides how to employ the innovation. First, firm 2 may follow an independent pricing strategy, selling the innovation separately to consumers. Second, firm 2 may precommit to a (mixed) bundling strategy, selling the innovation and the basic product as a single package. Third, firm 2 may choose a licensing strategy. Under the common assumption that the innovating firm has all the bargaining power, firm 2 proposes a contract that allows it to capture all the gains from licensing, subject to the constraint that firm 1 is willing to accept the contract. This assumption only affects the distribution of profits between the two firms and not the incentives to license. The results are unaffected by changing the distribution of bargaining power, provided that the licensor earns a nonzero share of the gains from licensing. Fourth, firm 2 may follow a licensing plus bundling strategy. For convenience, we assume that under this option, licensing and bundling decisions are made simultaneously, i.e., firm 2 commits to a bundling strategy and firms agree on the licensing contract simultaneously. Since side payments are possible (through the fixed-fee), a licensing or a licensing plus bundling strategy is beneficial whenever it leads to higher industry profits. In stage 2, firms set prices simultaneously, after having observed decisions made in stage 1.

We now determine the subgame-perfect (Nash) equilibria of the game. Only pure-strategy equilibria are considered. We first compare independent pricing, bundling, and licensing.

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In this model, the strategy where firm 2 offers the bundle, $x$, and both unbundled items, $x$ and $y$, is equivalent to independent pricing, where firm 2 offers only $x$ and $y$. This assumption simplifies the analysis considerably without affecting the main conclusions of the paper. Its implications are discussed later, in footnote 12.
3. Independent pricing, bundling, and licensing

Assume, first, that the innovating firm follows an independent pricing strategy, selling \( y \) separately to consumers, who can combine it with the product \( x \) offered by either of the two firms. In this case, firm 1 offers \( x \), charging a price \( p_{B1} \), and firm 2 offers \( x \), charging a price \( p_{B2} \), as well as \( y \), charging a price \( p_y \). Consumers who want to consume one unit of product \( x \) have to buy one unit of product \( x \) and one unit of \( y \), paying a total price \( p_B = p_B + p_y \).

The (Nash) equilibrium of the resulting pricing game can be characterized as follows. Due to competition between the two firms in \( x \), firm 1 sells \( x \) at a price \( p < c \), and firm 2 sells \( y \), at a price \( p_y > 0 \). Since consumers who want to consume one unit of \( x \) have to buy one unit of \( x \) from firm 1 and one unit of \( y \) from firm 2, the profit functions of firms 1 and 2 are given, respectively, by

\[
\Pi_1 = D_B(p_{B1}, p_{B1} + p_y) + D_B(p_{B1} + p_{y2}, p_{B1} + p_{y2}) \cdot (p_{B1} - c_1)
\]

\[
\Pi_2 = D_B(p_{B1} + p_{y2}, p_{B1}) \cdot p_{y2}.
\]

Define \( p_{B1}^{ip} \) and \( p_{y2}^{ip} \) as the independent pricing equilibrium prices.\(^8\)

Consider now that the innovating firm follows a (mixed) bundling strategy, offering \( x \) (composed of one unit of \( x \) and one unit of \( y \)), at a price \( p_{B2} \), and \( x \), at a price \( p_{B2} \). Firm 1 offers \( x \), charging a price \( p_{B1} \).

Due to competition between the two firms in \( x \), in equilibrium firm 1 sells \( x \), at a price \( p_{B1} < c_2 \) and firm 2 sells \( y \), at a price \( p_{B2} > c_2 \). The profit functions of firms 1 and 2 are given, respectively, by

\[
\Pi_1 = D_B(p_{B1}, p_{B2}) \cdot (p_{B1} - c_1)
\]

\[
\Pi_2 = D_B(p_{B2}, p_{B1}) \cdot (p_{B2} - c_2).
\]

Define \( p_{B1}^b \) and \( p_{B2}^b \) as the bundling equilibrium prices.\(^9\)

Bundling leads to the employment of inefficient production techniques, because firm 2 is inefficient in the production of \( x \), one of the components of \( x \). In contrast, under independent pricing only efficient production techniques are used. Furthermore, since \( p_{B1}^{ip} < c_2 \), the innovating firm may capture part of the efficiency gain relative to bundling. Under independent pricing, the innovating firm may benefit from the fact that consumers of the enhanced product buy the basic product

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\(^8\)For any \( p_y > 0 \), \( p_y(p_{B1} + p_y) > p_y \), and, consequently, we may restrict our attention to situations where \( D_B \) and \( D_y \) have the desirable properties mentioned above. To ensure the existence of an equilibrium of this pricing game, we assume that, for \( p_{B1} \in [c, c_2] \) and \( p_{y2} > 0 \), the profit function of firm 1 is concave in \( p_{B1} \) and the profit function of firm 2 is concave in \( p_{y2} \).

\(^9\)To ensure the existence of an equilibrium of this pricing game, we assume that, for \( p_{B1} < c_2 \) and \( p_{B2} > c_2 \), the profit function of firm 1 is concave in \( p_{B1} \) and the profit function of firm 2 is concave in \( p_{B2} \).
at a price \((p_{b1}^{ip})\) that is lower than its own cost of producing this product \((c_2)\). We may define \(e = c_2 - p_{b1}^{ip}\) as a measure of the part of the efficiency gain captured by firm 2. This is the \textit{inefficiency effect} of bundling relative to independent pricing.

By leading to a different equilibrium price \(p_{b1}\), bundling may also have a \textit{competition effect} on firm 2’s profit, which may either reinforce the inefficiency effect or have the opposite impact. However, since \(p_{b1}^{ip} - p_{b1}^{ip} \leq e\), even if the competition effect has the opposite impact, it is always (weakly) dominated by the inefficiency effect. As a consequence, firm 2’s equilibrium profit is greater or equal under independent pricing than under bundling.\footnote{Notice that, since the innovation \(y\) can only be consumed together with the basic product, bundling is not useful as a price discrimination device.} This result is stated in Lemma 1.

**Lemma 1.** The innovating firm’s profits are greater or equal under independent pricing than under bundling.

**Proof.** Assume first that firm 2 follows a bundling strategy. For a given pair of equilibrium prices \((p_{b1}^{b}, p_{e2}^{b})\), firm 2’s equilibrium profit is given by

\[
\Pi_{2}^{b} = D_{b}(p_{e2}^{b}, p_{b1}^{b}) \cdot (p_{b1}^{b} - c_2).
\]

Consider now that firm 2 follows an independent pricing strategy. Assume that, for \(p_{b1}^{p} = p_{b1}^{b}\), firm 2 sets a price \(p_{y2}^{p} = p_{e2}^{b} - c_2\). Its profit, \(\Pi_{2}^{p}\), is then given by

\[
\Pi_{2}^{p} = D_{b}(p_{e2}^{b}, p_{b1}^{b}) \cdot p_{y2}^{p}
\]

\[
= D_{b}(p_{e2}^{b} + p_{b1}^{b} - c_2, p_{b1}^{b}) \cdot (p_{e2}^{b} - c_2).
\]

To compare \(\Pi_{2}^{b}\) and \(\Pi_{2}^{p}\), it is convenient to distinguish three cases: \(p_{b1}^{b} = p_{b1}^{p}\), \(p_{b1}^{b} > p_{b1}^{p}\), and \(p_{b1}^{b} < p_{b1}^{p}\).

1. \(p_{b1}^{b} = p_{b1}^{p}\). In this case, \(\Pi_{2}^{b} \leq \Pi_{2}^{p}\) and \(\Pi_{2}^{b} \leq \Pi_{2}^{p}\), because \(p_{b1}^{p} \leq c_2\). Notice that if \(p_{b1}^{b} = p_{b1}^{p} = c_2\), then \(p_{y2}^{p} = p_{y2}^{p}\) and \(\Pi_{2}^{b} = \Pi_{2}^{p} = \Pi_{2}^{p}\).
2. \(p_{b1}^{b} < p_{b1}^{p}\). In this case, \(\Pi_{2}^{b} \leq \Pi_{2}^{p}\) and \(\Pi_{2}^{b} \leq \Pi_{2}^{p}\), because \(D_{bb} > 0\).
3. \(p_{b1}^{b} > p_{b1}^{p}\). In this case, since \(p_{b1}^{b} < p_{b1}^{p} \leq c_2\), we know that

\[
c_2 - p_{b1}^{ip} \geq p_{b1}^{b} - p_{b1}^{p} > 0.
\]

We also know that \(|D_{bb}| \geq |D_{bb}|\). Therefore, \(\Pi_{2}^{b} \leq \Pi_{2}^{p}\) and \(\Pi_{2}^{b} \leq \Pi_{2}^{p}\).

One can easily verify that \(\Pi_{2}^{b} \leq \Pi_{2}^{p}\), except if (1) \(p_{b1}^{b} = p_{b1}^{p} = c_2\) or if (2) \(p_{b1}^{ip} > c_2\) and \(|D_{bb}| = |D_{bb}|\). In these two cases, \(\Pi_{2}^{b} = \Pi_{2}^{p}\). \(\square\)

This result relates in an interesting way to Carbajo et al. (1990). These authors
assume that one good is produced by a monopolist which also produces a second good along with a competitor. They set up a model where bundling elicits less aggressive pricing from the rival. In our model, as in Carbajo et al. (1990), bundling may lead to less aggressive pricing by the rival (\( p_{b1}^b \) may be greater than \( p_{w1}^b \)). However, this effect is not enough to justify bundling. Since the innovating firm is inefficient in the production of the basic product, bundling leads to the employment of inefficient production techniques. As we have seen, this fact has a negative impact on the profits of firm 2 which (weakly) dominates the possible positive effect due to less aggressive pricing by firm 1.\(^{11}\)

We have just seen that, given our assumptions, bundling is not a profitable strategy. What about licensing? Licensing is clearly not beneficial. Licensing leads to aggressive competition in \( y \) (\( p_y \) comes down to marginal cost, \( c_y \)), reducing industry profits. It does not follow, however, that independent pricing is the optimal strategy. Indeed, even if there is no incentive to license and no incentive to bundle, there may still be an incentive to follow a licensing plus bundling strategy. This is the equilibrium strategy whenever it leads to higher industry profits than does independent pricing.\(^{12}\)

4. Independent pricing vs. licensing plus bundling

Assume now that firm 2 follows a licensing plus bundling strategy. In this case, both firms are able to produce \( x_a \) and \( y \). In addition, firm 2 commits to following a bundling strategy. Due to price competition between the two firms, in equilibrium

\(^{11}\) The result that, in this model, firm 2’s profits are always smaller or equal under bundling than under independent pricing would not hold if we considered pure bundling in addition to mixed bundling. Since under pure bundling firm 1 does not face the competition of firm 2 in \( x_a \), the equilibrium price \( p_{b1}^n \) (where the superscripts ‘pb’ indicate equilibrium under pure bundling) may be greater than \( c_a \). If \( p_{b1}^n \) is sufficiently greater than \( p_{w1}^n \), the competition effect may have the opposite impact and dominate the inefficiency effect. Therefore, as in Carbajo et al. (1990), bundling may be a more profitable strategy than independent pricing, because it elicits less aggressive pricing by the rival. However, if the competition effect reinforces the inefficiency effect or is (weakly) dominated by it, then \( \Pi_{b1}^r > \Pi_{w1}^r \), and the results presented below still hold.

\(^{12}\) This is so because, in our model, licensing and bundling decisions are made simultaneously. If the innovating firm precommits to bundling before licensing decisions are made, the situation is somewhat different. Once the innovating firm has committed to a bundling strategy, firm 1 only accepts the licensing contract if \( \Pi_{b1}^n > \Pi_{w1}^n \) (where the superscripts ‘lb’ indicate equilibrium under licensing and bundling). Knowing that the innovating firm only chooses a licensing plus bundling strategy if \( \Pi_{b1}^n > \Pi_{w1}^n \), Thus, we can no longer study the equilibrium strategy by comparing \( \Pi_{b1,2}^n \) and \( \Pi_{w1,2}^n \). This complicates the model without, however, affecting the conclusion that licensing and bundling may be optimal when neither licensing separately nor bundling separately are optimal. Notice, in particular, that for \( \Pi_{b1}^n > \Pi_{w1}^n \) (this happens, for example, if \( p_{w1}^b = p_{w1}^n = c_a \), \( \Pi_{b1}^n > \Pi_{w1}^n \) implies \( \Pi_{b1,2}^n > \Pi_{w1,2}^n \).
firm 1 supplies both \( x_\text{B} \) and \( y \), setting a pair of prices \((p_{\text{B}1}, p_{\text{y}1})\) such that \( p_{\text{B}1} + p_{\text{y}1} \leq c_2.\) Firm 1 chooses the prices \( p_{\text{B}1} \) and \( p_{\text{y}1} \) that maximize

\[
\Pi_{1+2} = D_1(p_{\text{B}1} + p_{\text{y}1}, p_{\text{B}1}) \cdot (p_{\text{B}1} + p_{\text{y}1} - c_1) + D_0(p_{\text{B}1}, p_{\text{B}1} + p_{\text{y}1}) \cdot (p_{\text{B}1} - c_1)
\]

s.t. \( p_{\text{B}1} + p_{\text{y}1} \leq c_2, \)

where \( \Pi_{1+2} \) is assumed to be concave both in \( p_{\text{B}1} \) and in \( p_{\text{y}1} \), with a maximum at \((p_{\text{B}1}^*, p_{\text{y}1}^*)\). Define \( p_{\text{B}1}^* \) and \( p_{\text{y}1}^* \) as the licensing and bundling equilibrium prices.

In general, licensing plus bundling has two effects, relative to independent pricing.

First, licensing plus bundling increases competition in the innovation, because under licensing both firms are able to produce the innovation. However, this increase in competition is mitigated through bundling. By committing to a bundling strategy, firm 2, the less efficient firm in the production of \( x_\text{B} \), accepts a cost disadvantage in the production of \( x_\text{B} \). This enables firm 2 to commit to competing less aggressively after licensing the innovation. As a result, for a given \( p_{\text{B}1} \), firm 1 may charge any price \( p_{\text{y}1} \leq c_2 - p_{\text{B}1} \) without inducing firm 2 to produce \( x_\text{B} \).

Second, licensing plus bundling leads to coordinated pricing of the basic product and the innovation. While under licensing plus bundling firm 1 supplies both \( x_\text{B} \) and \( y \), under independent pricing firm 1 supplies \( x_\text{B} \) and firm 2 supplies \( y \). This leads to sub-optimal pricing. In setting \( p_{\text{y}1} \), firm 2 does not internalize the impact of \( p_{\text{y}1} \) on sales of \( x_\text{B} \). Similarly, in setting \( p_{\text{B}1} \), firm 1 does not internalize the impact of \( p_{\text{B}1} \) on sales of \( y \).

To compare the equilibrium industry profits under independent pricing \( \Pi_{1+2}^{\text{ip}} \) and licensing plus bundling \( \Pi_{1+2}^{\text{ib}} \), it is convenient to fix \( c_1 \), and compare \( \Pi_{1+2}^{\text{ip}} \) and \( \Pi_{1+2}^{\text{ib}} \) for different values of \( c_2 \). Therefore, we define \( \Pi_{1+2}^{\text{ip}}(c_2) \) and \( \Pi_{1+2}^{\text{ib}}(c_2) \) for any given value of \( c_1 \).

Let us first characterize two extreme cases. For \( c_2 \) arbitrarily close to \( c_1 \), \( \Pi_{1+2}^{\text{ip}} > \Pi_{1+2}^{\text{ib}} \). Under licensing plus bundling, the two firms compete in both products and, consequently, industry profits are close to zero. Under independent pricing, the two firms compete in the basic product, but firm 2 has a monopoly in \( y \), making a positive profit. In contrast, for \( c_2 \geq p_{\text{B}1}^* + p_{\text{y}1}^* \), \( \Pi_{1+2}^{\text{ip}} > \Pi_{1+2}^{\text{ib}} \). In this case, licensing plus bundling does not increase competition in the innovation: firm 1 may charge \( p_{\text{B}1}^* \) and \( p_{\text{y}1}^* \) without facing the competition of firm 2 in \( y \). In addition, licensing plus bundling leads to coordinated pricing.

We still have to compare \( \Pi_{1+2}^{\text{ip}}(c_2) \) and \( \Pi_{1+2}^{\text{ib}}(c_2) \) for intermediate values of \( c_2 \),

\[\text{Under licensing plus bundling, the situations where firm 1 offers } x_\text{B} \text{ and } y; x_\text{B} \text{ and } x_\text{y}; \text{ and } x_\text{y}, x_\text{B} \text{ and } y \text{ are economically equivalent. Furthermore, since firm 1 is the most efficient firm in the production of } x_\text{y}, \text{pure bundling (the strategy of offering only } x_\text{y}) \text{ is clearly not a profitable strategy for this firm.}
\]
i.e., if $c_2$ is significantly greater than $c_1$, but smaller than $p_{B1}^* + p_{y1}^*$. Our assumptions about continuity of $D_B$ and $D_i$ and concavity of the profit functions ensure that both $\Pi_{1+2}^B(c_2)$ and $\Pi_{1+2}^b(c_2)$ are continuous in $c_2$ and that $\Pi_{1+2}^b(c_2)$ is concave. We also know that $\Pi_{1+2}^b(c_2)$ is increasing for $c_2 \in [c_2, p_{B1}^* + p_{y1}^*]$ and constant for $c_2 > p_{B1}^* + p_{y1}^*$, and that $\Pi_{1+2}^b(c_2)$ is constant for $c_2 > p_{B1}^*$, where $p_{B1}^*$ is the equilibrium price firm 1 would charge under independent pricing, if it did not have to face the competition of firm 2 in the production of $x_B$. Since $\Pi_{1+2}^B(c_2) > \Pi_{1+2}^b(c_2)$ for $c_2$ arbitrarily close to $c_1$, $\Pi_{1+2}^B(c_2) < \Pi_{1+2}^b(c_2)$ for $c_2 \geq p_{B1}^* + p_{y1}^*$, and both $\Pi_{1+2}^B(c_2)$ and $\Pi_{1+2}^b(c_2)$ are continuous, the two functions cross at least once. At this intersection,

\[
\frac{d\Pi_{1+2}^b}{dc_2} > \frac{d\Pi_{1+2}^B}{dc_2}.
\]

Now, assume that the condition

\[
\frac{d\Pi_{1+2}^b}{dc_2} > \frac{d\Pi_{1+2}^B}{dc_2}
\]

holds for $c_2 \in [c_1, p_{B1}^* + p_{y1}^*]$. Then the two functions cross only once for values of $c_2 \in [c_1, p_{B1}^* + p_{y1}^*]$. For a given $c_1$, there is a critical level of $c_2$, $c_2^*$, which defines two regions: one where $\Pi_{1+2}^B > \Pi_{1+2}^b$ and therefore independent pricing is optimal ($c_1 < c_2 < c_2^*$), and one where $\Pi_{1+2}^b > \Pi_{1+2}^B$ and therefore licensing plus bundling is optimal ($c_2 > c_2^*$). This result is formally stated in Proposition 1.

**Proposition 1.** If the innovator has a minor cost disadvantage ($c_2 < c_2^*$) independent pricing is the equilibrium strategy. If the innovator has a major cost disadvantage ($c_2 > c_2^*$), licensing plus bundling is the equilibrium strategy. If $c_2 = c_2^*$, both licensing plus bundling and independent pricing are equilibrium strategies.

The intuition is as follows. Both independent pricing and licensing plus bundling lead to the employment of efficient production techniques, since the basic product is produced by the most efficient firm. Furthermore, if the cost disadvantage of firm 2 in the production of the basic product is not too severe, rent dissipation due to increased competition in $y$ under licensing plus bundling is greater than rent dissipation due to the fact that, under independent pricing, prices for the basic product and the innovation are set by different firms. Therefore, $\Pi_{1+2}^B > \Pi_{1+2}^b$ and independent pricing is the optimal strategy. In contrast, if $c_2$ is

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**11**The consideration of the case where the two functions cross more than once would complicate the discussion without bringing any new insight. Notice, in particular, that the conclusion that $\Pi_{1+2}^b$ may be greater than $\Pi_{1+2}^B$, and, therefore, licensing plus bundling may be optimal when neither licensing separately nor bundling separately are optimal, remains valid.
high enough, rent dissipation due to competition in \( y \) under licensing plus bundling is smaller than rent dissipation due to lack of coordinated price setting under independent pricing. If this is the case, \( \Pi_{1+2}^{lb} > \Pi_{1+2}^{in} \) and licensing plus bundling is the optimal strategy.

The key point of our analysis is that licensing plus bundling has both an advantage and a disadvantage relative to independent pricing. First, by allowing the most efficient firm to produce both the basic product and the innovation, licensing plus bundling increases price coordination between the basic product and the innovation. Second, licensing plus bundling increases competition in the innovation, because under licensing both firms are able to produce the innovation. However, by choosing a bundling strategy, the innovating firm accepts a disadvantage in the production of the enhanced product (composed of one unit of the basic product and one unit of the innovation), credibly committing to compete less aggressively after licensing the innovation. As a result, licensing plus bundling may be an optimal strategy. Although we derive this result in a model where the basic products offered by both firms are homogeneous and firms compete in price, we believe that the idea is not limited to our model. The same intuition also applies to the situation where the basic products offered by both firms are horizontally differentiated, or to the situation where firms compete in quantities.

Previous research identifies incentives to license and incentives to bundle. We identify incentives to license and bundle. Even if both licensing and commodity bundling are unprofitable strategies, licensing plus bundling may be profitable. Licensing allows the licensee to supply both the basic product and the innovation. Commodity bundling mitigates competition resulting from the fact that, under licensing, both firms are able to produce the innovation. The combination of these two strategies may raise industry profits.\(^{15}\)

5. Exclusive licensing

In this section, we drop the assumptions that exclusive licensing is not possible and that firms are restricted to fixed-fee licensing contracts.

Whenever exclusive licensing is possible, this is the equilibrium strategy. The most efficient firm produces both the basic product and the innovation, without facing competition in \( y \).

As mentioned above, the assumption that firm 2 can use contractual language to

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\(^{15}\) The result that industry profits may be greater under licensing plus bundling than under independent pricing still holds if the innovation consists, not of a quality-improving innovation, but of a complement or substitute which can be consumed separately from the original product. Notice, however, that for such complements and substitutes this is not enough to ensure that bundling plus licensing is the optimal strategy. The result presented in Lemma 1 that bundling (without licensing) is never a profitable strategy does not hold. Bundling may be useful as a price discrimination device. For simplicity of exposition, in this paper we focus on quality-improving innovations, ignoring complements and substitutes that can be consumed separately from the original product.
credibly commit not to use the technology after licensing it is a strong one. Contractual language may not allow firm 2 to commit not to compete in y if firm 1 charges \( p_{y1}^{el} \) and \( p_{y1}^{el} \) (the superscripts 'el' indicate equilibrium under exclusive licensing). If this is the case, the innovating firm has to rely on other mechanisms to establish that commitment. As we will see, a royalty may be such a mechanism.

A royalty influences the firms’ decisions in two ways. First, a royalty reduces the licensor’s incentives to use the licensed technology, and thereby mitigates competition in y. This is because using the technology cannibalizes royalty revenues. Without a royalty, firm 2 has the incentive to compete in y if \( p_{y1} > 0 \), while with a royalty \( r \) firm 2 may no longer have this incentive when \( p_{y1} > 0 \), but \( p_{y1} \leq r \). Under these conditions, the profit firm 2 makes through royalty payments may be greater than the profit it would make by competing in y. Assume that firm 1 is charging the pair of prices \( (p_{B1}, p_{y1}) \), where \( p_{y1} \leq r \). By not producing y, firm 2 gets, through royalty payments, an amount \( RP \) given by

\[
RP = r \cdot D(p_{B1} + p_{y1}, p_{B1})
\]

By producing y, setting a price \( p_{y2} < p_{y1} \), firm 2 makes a profit \( \Pi_2^{E} \) given by

\[
\Pi_2^{E} = p_{y2} \cdot D(p_{B1} + p_{y2}, p_{B1})
\]

where \( D(p_{B1} + p_{y2}, p_{B1}) > D(p_{B1} + p_{y1}, p_{B1}) \), but \( p_{y2} < r \). Firm 2 has no incentive to compete in y if \( RP \geq \Pi_2^{E} \). Hence, firm 2 has no incentive to produce y if \( p_{y2} < p_{y1} \).

Second, a royalty changes the marginal cost of y on which firm 1 bases its pricing decisions. Interestingly, however, under specific conditions a royalty may be used as a means for firm 2 to credibly — and costlessly — commit not to use the licensed technology. This happens if the royalty eliminates firm 2’s incentive to compete in y for \( p_{y1} = p_{B1}^{el} \) and \( p_{y1} = p_{y1}^{el} \), without affecting the equilibrium prices set by firm 1. Proposition 2 specifies necessary and sufficient conditions for a royalty \( r^{*} = p_{y1}^{el} \) to achieve that. Define \( p_{B1}^{*} \) and \( p_{y1}^{*} \) as the equilibrium prices firm 1 charges when the licensing contract specifies a royalty \( r^{*} \).

**Proposition 2.** Assume that a fixed-fee licensing contract does not enable firm 2 to credibly commit not to use the licensed technology. Then a royalty \( r^{*} = p_{y1}^{el} \) can be used as a commitment device — without introducing any distortion in the pricing decisions of firm 1 — if and only if (1) \( |D_{EB}^{el}| \geq |D_{BE}^{el}| \), (2) \( p_{B1}^{el} = c_{2} \) and (3) \( p_{B1}^{el} = c_{2} \). Under these conditions, the optimal licensing contract includes a royalty \( r = r^{*} \).

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16 Consider, for example, the following preferences structure, proposed by Tirole (1988, p. 296) (see also Gabszewicz and Thisse, 1979; and Shaked and Sutton, 1982). Consumers’ preferences are given by \( U = \theta x - p \) if the consumer consumes one unit of quality x and pays price p, and by 0 otherwise. The parameter \( \theta \) of taste for quality is uniformly distributed between \( \theta^{-}<0 \) and \( \theta^{+}=\theta^{+}+1 \). In this case, it can be shown that a royalty \( r^{*} \) eliminates firm 2’s incentive to use the licensed technology for \( p_{B1} = p_{B1}^{el} \) and \( p_{y1} = p_{y1}^{el} \), without introducing any distortion in the pricing decisions of firm 1.
Proof. We first show sufficiency. Let us divide the proof of sufficiency into two steps.

(i) We first show that, for \( (1) \) \( |D_{EE}| > |D_{BE}| \), \( (2) \) \( p_{B1}^{el} = c_2 \) and \( (3) \) \( p_{B1}^{*r} = c_2 \), if licensing occurs and \( r = r^* \), firm 1 can charge \( p_{B1} = p_{B1}^{el} = c_2 \) and \( p_{y1} = p_{y1}^{el} \) without facing competition from firm 2 in \( y \). Under these conditions, firm 1 can charge the pair of prices \( p_{B1} = p_{B1}^{el} = c_2 \) and \( p_{y1} = p_{y1}^{el} \) without facing competition from firm 2 in \( y \), if and only if

\[
RP = p_{y1}^{el} \cdot D_k(c_2 + p_{y1}^{el}, c_2) \geq \Pi_2^E = p_{y2} \cdot D_k(c_2 + p_{y2}, c_2).
\]

\( \forall \) \( p_{y2} \leq p_{y1}^{el} \). Since \( p_1 \cdot D_k(p_0 + p_j, p_0) \) is, by assumption, differentiable and concave in \( p_j \), \( RP \geq \Pi_2^E \) if and only if

\[ D_k(c_2 + p_{y1}^{el}, c_2) + D_{EE} \cdot p_{y1}^{el} \geq 0. \]

This condition implies that by competing in \( y \), with a price \( p_{y2} \) slightly lower than \( p_{y1}^{el} \), firm 2 (weakly) decreases its profit. Since, by assumption, \( p_{B1}^{el} = c_2 \), \( p_{y1}^{el} \) is determined by the first-order condition

\[
\frac{\partial \Pi_{1+y2}}{\partial p_{y1}} = D_k(c_2 + p_{y1}, c_2) + D_{EE} \cdot p_{y1} + (D_{BE} + D_{EE}) \cdot (c_2 - c_1) = 0.
\]

For \( |D_{EE}| > |D_{BE}| \), this implies

\[ D_k(c_2 + p_{y1}, c_2) + D_{EE} \cdot p_{y1}^{el} \geq 0. \]

(ii) We now verify that in fact \( p_{y1}^{el} = p_{y1}^{el} \). In equilibrium firm 1 sets the price \( p_{y1} \) that maximizes

\[
\Pi_1 = D_k(c_2 + p_{y1}, c_2) \cdot (c_2 + p_{y1} - c_1 - r^*) + D_k(c_2 + p_{y1}, c_2) \cdot (c_2 - c_1)
\]

s.t. \( p_{y1} \leq p_{y1}^{el} = r^* \).

Ignore for a moment the restriction on \( p_{y1} \). For \( p_{B1} = p_{B1}^{el} = c_2 \), \( p_{y1} \) is given by the corresponding first-order condition

\[
\frac{\partial \Pi}{\partial p_{y1}} = D_{EE} \cdot (c_2 + p_{y1} - c_1 - r^*) + D_k(c_2 + p_{y1}, c_2) + D_{BE} \cdot (c_2 - c_1) = 0.
\]

From the first-order condition it is easy to verify that without the restriction on \( p_{y1} \), for any royalty \( r^* > 0 \), and in particular for \( r^* = r^* \), firm 1 would charge a price \( p_{y1} > p_{y1}^{el} \). Consider now the restriction \( p_{y1} \leq p_{y1}^{el} \). Due to the concavity of firm 1’s profit on \( p_{y1} \), the best firm 1 can do is to charge \( p_{y1}^{el} = p_{y1}^{el} \).

We now sketch the proof of necessity. For \( p_{B1}^{el} < c_2 \) or \( p_{B1}^{*r} \neq p_{B1}^{el} \) it can easily be verified by inspection of the first-order conditions that \( p_{B1}^{el} = p_{B1}^{el} \). As a result, licensing introduces a distortion in the pricing decisions of the licensee. Clearly, if
a royalty \( r = r^* \) cannot be used as a means for firm 2 to credibly commit not to use the licensed technology if firm 1 charges a price \( p_{y_1}^e \). For \( p_{y_1} = p_{y_1}^e \), firm 2 has the incentive to produce \( y \).

The intuition behind this result is the following. A royalty reduces the licensor’s incentives to use the licensed technology, and thereby mitigates competition in \( y \). This is so because using the technology cannibalizes royalty revenues. Consider, in particular, a royalty \( r^* = p_{y_1}^e \). If, for \( p_{y_1} = p_{y_1}^e \) and \( y_{y_1} = p_{y_1}^e \), \( RP \geq \Pi_2^e \forall \ p_{y_2} < p_{y_1} \), firm 1 may charge the exclusive licensing equilibrium prices without facing competition from firm 2 in \( y \). A royalty \( r^* \) also increases the marginal cost of \( y \) on which firm 1 bases its pricing decisions. This implies that, without competition from firm 2 in \( y \), firm 1 would charge a price \( p_{y_1} > p_{y_1}^e \). However, firm 1 cannot set a price \( p_{y_1} > p_{y_1}^e \) without inducing firm 2 to compete in \( y \), setting a price \( p_{y_2} < p_{y_1} \). Therefore, in equilibrium firm 1 sets the pair of prices \(( p_{y_1}^e, p_{y_1}^e )\). The royalty solves the problem of increased competition in \( y \) due to licensing without introducing a distortion in the pricing decisions of firm 1.

The implications of different types of licensing contracts have been extensively studied in the literature (e.g., Kamien and Tauman, 1984, 1986; Katz and Shapiro, 1986; Kamien et al., 1992). These papers show that in the case of process innovations fixed-fees are superior to royalties. There are, however, some exceptions: royalties may be optimal in the presence of information asymmetries (e.g., Gallini and Wright, 1990; Beggs, 1992), when firms produce differentiated products (e.g., Muto, 1993), or as a mechanism to facilitate collusion (e.g., Shapiro, 1985). In this paper, we show that in the case of quality-improving innovations a royalty may be used as a commitment device enabling the licensor to credibly — and costlessly — establish exclusivity. As a result, the optimal licensing contract may include a royalty.

6. Conclusion

Most of the literature on innovation has been concerned with the firms’ research and development decisions, namely with the interaction between market structure and the firms’ incentives to innovate (e.g., Lee and Wilde, 1980; Dasgupta and Stiglitz, 1980; Reinganum, 1982, 1983). However, after developing innovations, firms have to decide when and how to employ them. Several authors have studied the timing of adoption of innovations, considering the preemptive aspects of the adoption decision (e.g., Reinganum, 1981a,b; Fudenberg and Tirole, 1985, 1987). Others have focused on how firms should employ their innovations in order to fully appropriate their potential rents. The literature on technology transfer through licensing examines the incentives a firm with a new, proprietary technology may have for licensing the innovation to a competitor (e.g., McGee, 1966; Salant, 1984; Gallini, 1984; Gallini and Winter, 1985; Katz and Shapiro, 1985; Shepard, 1987). And the literature on commodity bundling identifies incentives to sell two or more
products or services in a single package, as opposed to independent pricing (e.g., Stigler, 1963; Adams and Yellen, 1976; Schmalensee, 1982, 1984; Carbajo et al. 1990; Whinston, 1990).

While the licensing literature compares licensing and exclusive use of the innovation, and the bundling literature compares bundling and independent pricing, this paper compares independent pricing, bundling, licensing and licensing plus bundling. We show that licensing and bundling may be complementary strategies. Even if firms lack the incentive either to license or to bundle, they may still have the incentive to follow a licensing plus bundling strategy. The incentives to bundle and to license we identify are different from those previously considered in the literature. In our model, bundling provides a mechanism for an innovating firm to credibly commit to act less aggressively after licensing a complementary product or service or a new component to a more efficient competitor. Licensing may then raise industry profits by inducing coordinated pricing of the basic product and the innovation. Furthermore, even though the effect of licensing plus bundling on equilibrium prices and, hence, on consumer surplus is unclear, this strategy may well increase social welfare.

References


