THE STRATEGIC DEPLOYMENT OF RESOURCES

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ABSTRACT

The 'resource-based' view of strategy has identified which resources may lead to sustainable competitive advantages and how those resources may either be acquired or developed internally. This paper studies a complementary issue, viz. how resources should be deployed in order to fully realize their rent potential. Three deployment strategies are compared: captive use, where the firm uses the resource to enhance the competitive position of its own products; resource sharing, where the firm shares the resource with one or more competitors, for example through licensing agreements; and independent selling, where the firm incorporates the resource in an add-on or an up-grade which is sold separately to consumers. We show that a captive use strategy is often dominated by resource sharing or independent selling. Thus, a narrowly focused strategy of pursuing competitive advantage in product markets will frequently fail to capture the full rent potential of strategic resources.

1. INTRODUCTION

The 'resource-based' view of strategy (e.g., Rumelt 1984, 1987; Wernerfelt, 1984, 1989; Barney 1986, 1991; Dierickx and Cool, 1989; Prahalad and Hamel, 1990; Conner, 1991; Grant, 1991; Amit and Schoemaker, 1993; Peteraf, 1993; Henderson and Cockburn, 1994) maintains that firms may be heterogeneous with respect to the bundle of resources they control. Furthermore, since some of these resources, such as a firm's reputation or other information-based resources, cannot be traded in factor markets and are difficult to accumulate and imitate, resource heterogeneity may persist over time. The 'resource-based' view has enriched our understanding about which resources lie at the heart of the firm's competitive position, and, therefore, are worth protecting and developing (e.g., Wernerfelt, 1984; Barney 1986, 1991; Dierickx and Cool, 1989; Prahalad and Hamel, 1990) and about the accumulation process of nontradeable resources, which must be developed inside the firm, in a complex and time-consuming process (e.g., Hedlund and Nonaka, 1993; McGrath, MacMillan and Venkataraman, 1995; Teece, Pisano and Shuen, 1997).

Besides choosing which resources to develop and how to accumulate them, firms have to decide how to *deploy* their unique (or scarce) resources in order to fully realize their potential rents (e.g., Wernerfelt, 1984; Gabel, 1984). The consideration of the different deployment alternatives requires firms to think beyond product market positioning and to address the broader question of how to fully exploit the potential rents associated with their valuable assets.

The following example may illustrate the problem. Suppose that Valmet, a Finnish manufacturer of paper machines, develops a unique and highly effective pollution control device, which substantially reduces pollution originated by paper machines. As is usually the case, this asset may be deployed in several ways. First, Valmet may use the asset *captively*, i.e., it may incorporate the innovation in its own paper machines to strengthen its product-market position. Paper producers who want to benefit from the innovation have to buy their paper machines from Valmet. Alternatively, Valmet may deploy the unique asset *noncaptively*, either by *sharing* it with other paper machine manufacturers, through licensing contracts, outsourcing agreements or other types of collaborative arrangements, or by *selling* the pollution control device *independently* to paper producers as an add-on or an upgrade. In other words, Valmet can use the pollution control technology captively, share it with its competitors, or independently sell a separate module to paper makers.

The deployment decision has been extensively studied in the Strategic Management literature from a Transaction Cost perspective (e.g., Teece, 1986, 1987; Hennart, 1988, 1991; Kogut, 1988; Hill, 1992; Chi, 1994). Additional insights can be gained by studying the performance implications of the interactions among competitors' resource positions and deployment strategies, under given environmental constraints. Indeed, some authors (e.g., Conner, 1991; Mahoney and Pandian, 1992) argue that the 'resource-based' view can be enriched by incorporating game-theoretic models that study the implications of such complex interactions. As Conner puts it: "It is apparent that a resource-based approach views a firm's performance as resulting from the simultaneous interaction of at least three forces: the firm's own asset base; the asset bases of competitors; and constraints emanating

from the broader industry and public policy environment. Although further development of the resource-based approach will benefit from employment of a variety of research methods, developing the theoretical implications of such complex interactions is an area in which the resource-based theory may gain from application of the new IO's game-theoretic techniques" (1991, pp. 145).[1]

In this paper, we build a game-theoretic model to study rent-maximizing deployment options of strategic assets. In order to study a broad range of deployment options, it is necessary to examine the case of an asset that can not only be deployed captively, but can also be sold independently to consumers or shared with competitors through collaborative agreements. For instance, the case of a cost-reducing process innovation would be too restrictive: while it can be deployed captively or shared with competitors, it cannot be sold independently to consumers. In contrast, innovations that improve the quality of an existing product or service usually allow for a broader range of deployment options.

The recent transformations at General Electric (GE) illustrate the importance of quality-improving innovations and how they may be deployed. 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 a departure from captive use. 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 no longer rely on keeping these resources in-house. For

example, GE Medical Systems signed exclusive multi-year service deals with big hospital chains which involve servicing rival manufacturers' medical equipment; and GE Aircraft Engines signed a deal with British Airways (BA), under which GE will do 85% of the engine maintenance work on BA's entire fleet, including engines made by rivals Rolls-Royce and Pratt & Whitney. In these examples, GE is appropriating rents through independent selling. In other businesses, GE is sharing resources with firms that have complementary assets. For instance, GE Transportation formed a joint venture with electronics specialist Harris Corp. to design and sell global-positioning systems similar to those used in air-traffic control; GE Capital is building a global computer outsourcing business and, in 1995, joined forces with Anderson Consulting to beat major competitors for a contract to manage LTV Corp.'s mainframe-based computer needs; and GE Power Systems is managing power plants for independent power producers. According to *Business Week*, GE's 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).

The deployment decision of quality-improving innovations is particularly interesting because, as GE's example illustrates, the owner of such an innovation often faces all the deployment alternatives identified above. The innovator may use the innovation captively, i.e., it may incorporate the innovation in its own product, in an attempt to create a vertical (or quality) differentiation advantage;[2] it may share the new technology with a competitor, for example through a licensing contract; and it may follow an independent selling strategy, i.e., it may sell the complementary product or service as an add-on or an

upgrade to consumers, who may combine it with the basic (or original) product offered by competitors.[3]

In this paper, we model how cost differences and the range of feasible licensing contracts affect the deployment of quality improving innovations.[4] The paper is organized as follows. In Section 2, we introduce the four-stage game-theoretic model. In Section 3, we study the case where the innovator is a *high-cost producer*. In Section 4, we study the deployment decision when the innovator is a *low-cost producer*. In Section 5, we discuss the results.

2. THE MODEL

Consider an industry with two firms, indexed by j=1,2, which produce a homogeneous product x_B (the basic or original product), at a constant marginal cost c_j. In addition, one of the firms, say firm 2, developed an innovation y which, when used together with product x_B, results in an enhanced (higher quality) product x_E. Specifically, one unit of the enhanced product x_E consists of one unit of the basic product x_B plus one unit of the innovation y. The innovation y results in vertical differentiation: if both products are offered at the same price, consumers strictly prefer to buy product x_E to product x_B. Without loss of generality, we may assume that the marginal cost of production of the innovation, c_y, equals zero. The innovator, firm 2, may either be a low-cost producer ($c_2 \leq c_1$) or the high-cost producer ($c_2 > c_1$) of the basic product.

Define $D_B(p_B,p_E)$ as the demand for product x_B, where p_B is the price of the basic product x_B and p_E is the price of the enhanced product x_E. Similarly, $D_E(p_E,p_B)$ is the demand for product x_E. $D_E(p_E,p_B)$ is strictly positive for all non negative prices. $D_B(p_B,p_E)$ is 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 $p_B \geq p_E$ (due to vertical differentiation). 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 $p_B<p_E$, $D_{ii}=\partial D_i/\partial p_i<0$, $D_{ik}=\partial D_i/\partial p_k>0$ and $|D_{ii}| \geq |D_{ik}|$, where i,k=B,E and $i \neq k$.

The timing of the model is as follows (Figure 1). In stage 1, the *deployment stage,* firm 2 chooses from three deployment options: licensing, independent selling and captive use. If the innovator decides to offer a licensing contract to firm 1, we arrive at stage 2, the *licensing decision stage,* where firm 1 either accepts or refuses the contract. If the licensing contract is refused by firm 1, firm 2 decides, in stage 3, the *fall-back deployment stage,* either to use the innovation captively or to follow an independent selling strategy. We then arrive at stage 4, the *pricing stage,* where both firms simultaneously set prices after observing the deployment decision. If firm 1 accepts the contract, the fall-back deployment stage is skipped and we directly arrive at stage 4, the pricing stage. If in stage 1 firm 2 selects one of the other deployment options, independent selling or captive use, we immediately arrive at stage 4, the pricing stage.[5]

[INSERT FIGURE 1 ABOUT HERE]

Several licensing contracts are considered. In general, a licensing agreement may stipulate a fixed-fee F and a royalty r per unit of x_E produced by the licensee. However, a

royalty may not always be feasible. For example, it may be difficult for the licensor to monitor the licensee's output, which is necessary to enforce a contract specifying a royalty. Thus, we devote a part of this paper to situations where the licensor is restricted to fixed-fee licensing contracts.

A license may be exclusive or nonexclusive. 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 innovator. It is important to note that explicit contractual language does not necessarily guarantee that the license will effectively be exclusive. A common problem is that the licensor may be able to invent around the licensed innovation. After all, it is the licensor who came up with the innovation and who wrote the patent, and hence it is the licensor who is in the best position to invent around it. If explicit contractual language is not able to prevent the licensor to do so, then, effectively, the license will be nonexclusive. We consider both the case where exclusive licensing is possible (i.e., the contract is "water-tight") and the case where exclusive licensing is not possible.

In our model, firm 2 proposes the licensing contract and firm 1 either accepts or refuses it. This corresponds to assuming that the innovator has all the bargaining power. In this situation, the optimal policy for firm 1 is to propose a royalty that maximizes the joint profits of the two firms, and a fixed-fee that allows it to capture all the gains from licensing, subject only to ensuring that the licensee is willing to accept the contract.[6] The assumption that the innovator has all the bargaining power is innocuous, in the sense that it only affects the distribution of profits between the two firms (which is not our concern in this paper), and not the optimality of licensing relative to the other deployment decisions. Since side

payments are possible (through the fixed-fee), licensing is beneficial whenever it leads to higher joint profits.

We first consider the situation where the innovator is the high-cost producer ($c_2>c_1$). We then consider the situation where the innovator is a low-cost producer ($c_2\leq c_1$).

3. DEPLOYMENT DECISION WHEN THE INNOVATOR IS THE HIGH-COST PRODUCER

When the innovator has a cost disadvantage in the production of the basic product ($c_2>c_1$), production efficiency favors either licensing or independent selling over captive use. However, to track the implications of market interaction and competition, we have to characterize the Subgame Perfect equilibria of the overall game. Only pure strategies equilibria are considered. We first compare captive use and independent selling.

3.1. Captive Use *vs.* Independent Selling

Assume first that firm 2 uses the quality-improving innovation captively, and thus sells the enhanced product x_E in the product market. In this case, firm 1 offers x_{B1}, charging a price p_{B1}, and firm 2 offers x_{B2}, charging a price p_{B2}, and x_{E2}, charging a price p_{E2}.

The Nash equilibrium of the resulting pricing game can be characterized as follows. Due to competition between the two firms in x_B, in equilibrium firm 1 (the low-cost firm)

sells x_{B1} charging a price $p_{B1}^{cu} \leq c_2$, and firm 2 sells x_{E2} charging a price p_{E2}^{cu} (the superscripts "cu" indicate equilibrium under captive use).[7] The equilibrium profits of firms 1 and 2 are given, respectively, by

$$\Pi_1^{cu} = D_B(p_{B1}^{cu}, p_{E2}^{cu}) \cdot (p_{B1}^{cu} - c_1)$$

$$\Pi_2^{cu} = D_E(p_{E2}^{cu}, p_{B1}^{cu}) \cdot (p_{E2}^{cu} - c_2).$$

Suppose now that firm 2 sells the enhancement independently as an add-on or as an upgrade to consumers who can then combine it with the basic product x_B offered by both firms. In this case, firm 1 offers x_{B1} charging a price p_{B1}, and firm 2 offers x_{B2} charging a price p_{B2} as well as y charging a price p_y.

The Nash equilibrium of the resulting pricing game can be characterized as follows. Since firm 1 faces competition of firm 2 in x_B, in equilibrium firm 1 charges a price $p_{B1}^{is} \leq c_2$, supplying the whole market for x_B, and firm 2 sells y, charging a price $p_y^{is} > 0$ (the superscripts "is" indicate equilibrium under independent selling).[8] The equilibrium profits of firms 1 and 2 are given, respectively, by

$$\Pi_1^{is} = [D_B(p_{B1}^{is}, p_{B1}^{is} + p_y^{is}) + D_E(p_{B1}^{is} + p_y^{is}, p_{B1}^{is})] \cdot (p_{B1}^{is} - c_1)$$
$$\Pi_2^{is} = D_E(p_{B1}^{is} + p_y^{is}, p_{B1}^{is}) \cdot p_y^{is}.$$

To compare the innovator's profits under captive use and independent selling assume, for a moment, that the price of the basic product is the same under these two deployment alternatives ($p_{B1}^{cu} = p_{B1}^{is}$). In this case, the innovator's profits under independent selling are always greater than or equal to its profits under captive use ($\Pi_2^{is} \geq \Pi_2^{cu}$). The intuition is as follows. Independent selling leads to low-cost production, because in equilibrium the basic product is produced only by the most efficient firm. Since the price

charged by firm 1 for the basic product is smaller or equal than firm 2's cost of production of that product ($p_{B1}^{is} \leq c_2$), the innovator may be able to capture part of the efficiency gain. The innovator may benefit from the fact that, under independent selling, consumers of the enhanced product buy the basic product at a price that is lower than its own cost to produce this product. We may define $e=c_2-p_{B1}^{ds}$ as a measure of the part of the efficiency gain captured by firm 2. This is the *cost reduction effect* of selling the innovation independently to consumers, instead of using it captively.

Now let us drop the assumption that $p_{B1}^{is}=p_{B1}^{cu}$. Indeed, the deployment decision affects industry structure, and, therefore, it may influence the equilibrium price p_{B1}. From the first-order conditions it is easy to verify that p_{B1}^{cu} may be greater than, equal to, or smaller than p_{B1}^{is}. Therefore, by leading to a different equilibrium price p_{B1}, independent selling may have a second effect on firm 2's profit. This *competition effect* may either reinforce the efficiency effect or have the opposite impact. However, even if the competition effect has the opposite impact, it is always (weakly) dominated by the efficiency effect. This is so because $p_{B1}^{cu}-p_{B1}^{is} \leq e$. As a consequence, firm 2's equilibrium profits are greater or equal under independent selling than under captive use.[9]

3.2. Independent Selling vs. Licensing

Since captive use is dominated by independent selling, optimal deployment will either be independent selling or licensing. To compare these two deployment options, we only need to look at joint profits, the "total size of the pie". The reason is that under

licensing profits can be redistributed at will through the fixed licensing fee. Indeed, this fixed-fee is a side payment which transfers profits between the two companies without affecting joint-profits. This implies that both firms can be made better off under licensing if and only if joint profits are greater under this deployment option than under independent selling.

3.2.1. Exclusive Licensing

Whenever possible, exclusive licensing will be preferred over nonexclusive licensing. The major drawback of nonexclusive licensing is increased product market competition, and, consequently, lower joint profits. Furthermore, if the contract is "water-tight", i.e., exclusivity is effectively guaranteed by explicit contractual language, the optimal licensing contract sets no royalty (r=0). This ensures that the licensee (firm 1) makes its decisions according to its true marginal cost, thus maximizing joint profits.

The Nash equilibrium of the ensuing pricing game can be characterized as follows. Firm 1 supplies both x_B and x_E, charging a price $p_{B1} \leq c_2$ (because the two firms compete in x_B). Firm 1 chooses the prices p_{B1}^{el} and p_{E1}^{el} that maximize

$$\Pi_{1+2} = D_E(p_{E1}, p_{B1}) \cdot (p_{E1} - c_1) + D_B(p_{B1}, p_{E1}) \cdot (p_{B1} - c_1)$$

$$\text{s.t. } p_{B1} \leq c_2,$$

where Π_{1+2} denotes the joint profits of the two firms and the superscripts "el" indicate equilibrium under exclusive licensing.[10]

Both independent selling and exclusive licensing lead to cost-efficient production. However, exclusive licensing has an advantage over independent selling: it leads to *coordinated pricing of the basic and the enhanced products*. Under independent selling, firm 1 sells x_B, while firm 2 sells y. The problem with this arrangement is that firm 1's pricing decision does not take into account the impact of the price of x_B on sales of y. Similarly, firm 2's pricing decision for the add-on does not internalize the impact of the price of y on sales of x_B. The result is sub-optimal pricing. In contrast, exclusive licensing involves coordinated pricing of the different products, as they are sold by the same firm.[11] Therefore, when exclusive licensing is possible, it is the optimal deployment decision for a high-cost innovator.[12]

3.2.2. Nonexclusive Licensing

Consider now the situation where exclusive licensing is not possible. Assume also, for the moment, that firms are restricted to fixed-fee licensing contracts.

The Nash equilibrium of the nonexclusive licensing pricing game can be characterized as follows. Due to price competition between the two firms in x_B and x_E, firm 1 supplies both products, charging prices $p_{B1}^1 \leq c_2$ and $p_{E1}^1 \leq c_2$ (the superscript "1" indicates equilibrium under nonexclusive licensing).

Firm 1 chooses the prices p_{B1}^1 and p_{E1}^1 that maximize

$$\Pi_{1+2} = D_E(p_{E1}, p_{B1}) \cdot (p_{E1} - c_1) + D_B(p_{B1}, p_{E1}) \cdot (p_{B1} - c_1)$$

s.t. $p_{B1} \leq c_2$ and $p_{E1} \leq c_2$.

Like independent selling, nonexclusive licensing also allows for low-cost production. However, nonexclusive licensing has both an advantage and a disadvantage relative to independent selling: while nonexclusive licensing *involves coordinated pricing of the basic and the enhanced products,* it also *introduces competition in the enhanced product.* As we will see below, if the rent dissipation due to increased competition in the enhanced product is significant, joint profits are greater under independent selling than under nonexclusive licensing.

To compare the equilibrium joint profits under independent selling (Π_{1+2}^{is}) and nonexclusive licensing (Π_{1+2}^{l}), it is convenient to fix c_1, and compare Π_{1+2}^{is} and Π_{1+2}^{l} for different values of c_2. Therefore, we define $\Pi_{1+2}^{is}(c_2)$ and $\Pi_{1+2}^{l}(c_2)$ for any given value of c_1. Let us first characterize two extreme cases.

If c_2 is arbitrarily close to c_1, joint profits are greater under independent selling than under nonexclusive licensing and, consequently, independent selling is the optimal deployment option. Under nonexclusive licensing, the two firms compete in both products, and, consequently, joint profits are close to zero. Under independent selling, the two firms compete in the basic product, but firm 2 has a monopoly in y, making a positive profit. As a result, joint profits are greater than zero.

If $c_2 \geq p_{E1}^*$, joint profits are greater under nonexclusive licensing than under independent selling and, consequently, nonexclusive licensing is the optimal deployment option. If $c_2 \geq p_{E1}^*$, firm 2 does not have the incentive to use the innovation after licensing it nonexclusively to firm 1. The licensee may charge a price p_{E1}^* without inducing the

innovator to compete in x_E. Therefore, the license is *de facto* exclusive. Equilibrium prices and joint profits are the same as under exclusive licensing.

What happens for intermediate values of c_2, that is, if c_2 is significantly greater than c_1, but smaller than p_{E1}^*? Our assumptions about continuity of D_B and D_E and concavity of the profit functions ensure that both $\Pi_{1+2}^{is}(c_2)$ and $\Pi_{1+2}^{l}(c_2)$ are continuous in c_2 and that $\Pi_{1+2}^{l}(c_2)$ is concave. We also know that $\Pi_{1+2}^{l}(c_2)$ is increasing for $c_2 \in]c_1, p_{E1}^*]$ and constant for $c_2 > p_{E1}^*$ and that $\Pi_{1+2}^{is}(c_2)$ is constant for $c_2 > p_{B1}^{is*}$, where p_{B1}^{is*} is the equilibrium price firm 1 would charge under independent selling, if it did not have to face the competition of firm 2 in x_B. The fact that $\Pi_{1+2}^{is}(c_2) > \Pi_{1+2}^{l}(c_2)$ for c_2 arbitrarily close to c_1, and $\Pi_{1+2}^{is}(c_2) < \Pi_{1+2}^{l}(c_2)$ for $c_2 \geq p_{E1}^*$, together with the fact that both $\Pi_{1+2}^{is}(c_2)$ and $\Pi_{1+2}^{l}(c_2)$ are continuous, imply that there is a value of c_2, c_2^i, where the two functions intersect. A typical representation of $\Pi_{1+2}^{is}(c_2)$ and $\Pi_{1+2}^{l}(c_2)$ is given in Figure 2. In Figure 2 we identify two regions: one where independent selling is the optimal deployment option ($c_1 < c_2 < c_2^i$) and one where nonexclusive licensing is the optimal deployment option ($c_2 > c_2^i$).

[INSERT FIGURE 2 ABOUT HERE]

The intuition is as follows. If firm 2's cost disadvantage relative to firm 1 is small (i.e., for values of c_2 sufficiently close to c_1), rent dissipation due to increased competition in the enhanced product under nonexclusive licensing is greater than losses due to lack of coordinated pricing under independent selling. Therefore, joint profits are greater under independent selling than under licensing and, therefore, independent selling is the optimal deployment decision. As c_2 increases relative to c_1, rent dissipation due to competition in the enhanced product under nonexclusive licensing decreases. If firm 2's cost disadvantage

is large, rent dissipation due to competition in the enhanced product under nonexclusive licensing is smaller than losses due to lack of coordinated pricing under independent selling. If this is the case, joint profits are greater under nonexclusive licensing than under independent selling, and, therefore, nonexclusive licensing is the optimal deployment decision.[13]

We now consider the case where the licensing contract may include a royalty. In general, this case involves a tradeoff.

First, a royalty reduces the licensor's incentives to use the licensed technology, and thereby mitigates competition in the enhanced product. This is because using the technology cannibalizes the licensor's royalty revenues. Without a royalty, the licensor has the incentive to compete in the enhanced product whenever $p_{E1}>c_2$. With a royalty r the licensor may no longer have this incentive when $p_{E1}>c_2$, but $p_{E1}\leq c_2+r$.

More specifically, assume that firm 1 sets the pair of prices (p_{B1},p_{E1}), where $p_{E1}\leq c_2+r$. By not producing the enhanced product, firm 2 gets, through royalty payments, an amount, RP, given by

$$RP = r \cdot D_E(p_{E1}, p_{B1}).$$

By producing the enhanced product, charging a price $p_{E2}<p_{E1}$, firm 2 makes a profit Π_2^E, equal to

$$\Pi_2^E = (p_{E2} - c_2) \cdot D_E(p_{E2}, p_{B1}),$$

where $D_E(p_{E2},p_{B1})>D_E(p_{E1},p_{B1})$, but $p_{E2}-c_2<r$. Firm 2 has no incentive to compete in the enhanced product if $RP\geq\Pi_2^E$, for any $p_{E2}<p_{E1}$.

Second, a royalty introduces a distortion in the pricing behavior of the licensee. It changes the marginal cost of the enhanced product on which firm 1 bases its decisions from c_1 to $c_1'=c_1+r$.

Thus, whether the licensing contract should include a royalty or not is unclear, as it depends on the interplay of these two effects. However, there is a special case where the optimal licensing contract definitely includes a royalty, because it allows firms to replicate the exclusive licensing outcome. Indeed, under certain circumstances, a royalty $r^*=p_{E1}^{el}-c_2$ eliminates the innovator's incentives to compete in the enhanced product for $p_{B1}=p_{B1}^{el}$ and $p_{E1}=p_{E1}^{el}$, *without* introducing any distortion in the pricing decisions of firm 1.[14]

Consider a royalty $r^*=p_{E1}^{el}-c_2$. If, for $p_{B1}=p_{B1}^{el}$ and $p_{E1}=p_{E1}^{el}$, $RP\geq\Pi_2^E$, for any $p_{E2}<p_{E1}$, firm 1 may charge the exclusive licensing equilibrium prices without facing competition from firm 2 in the enhanced product. A royalty r^* also changes the marginal cost c_1 to $c_1'=c_1+r^*$. This implies that, without competition from firm 2 in x_E, firm 1 would charge a price $p_{E1}>p_{E1}^{el}$. However, firm 1 cannot set a price $p_{E1}>p_{E1}^{el}$ without inducing firm 2 to compete in the enhanced product, setting a price $p_{E2}<p_{E1}$. Therefore, the best firm 1 can do is to set the pair of prices $(p_{B1}^{el},p_{E1}^{el})$. As a result, the royalty solves the problem of increased competition in x_E due to nonexclusive licensing without introducing a distortion in the pricing decisions of firm 1. Joint profits are the same as under exclusive licensing.

4. DEPLOYMENT DECISION WHEN THE INNOVATOR IS A LOW-COST PRODUCER

If the innovator has a cost advantage in the production of the basic product ($c_2<c_1$) or if the two firms are equally cost efficient ($c_2=c_1$), the innovator has no incentive to license the innovation or to sell it independently to consumers. Captive use is the optimal deployment decision. This is so for two reasons. First, licensing or independent selling do not lower production costs and, therefore, do not create any efficiency gains. Second, by using the innovation noncaptively, the innovator loses its monopoly in the enhanced product (or in one of its components, the basic product to be consumed with the quality-improving innovation), thereby inducing rent dissipation due to increased competition.

5. CONCLUSION

Let us now go back to the problem, presented in the introduction, where Valmet, a Finnish manufacturer of paper machines, develops a unique and highly effective pollution control device. Valmet's decision problem is now clear. It is captured by Figure 3.

[INSERT FIGURE 3 ABOUT HERE]

Captive use is not in general the optimal deployment choice. It is optimal only in one case, where the innovator is also the most cost efficient manufacturer. It is far from clear that one and the same firm will, in general, excel in both innovative and manufacturing

capabilities. Put differently, in all cases where innovations are generated by firms which are *not* the most cost efficient producer in their industries, captive use should be abandoned in favor of licensing or independent selling. In those cases, exclusive licensing should be preferred whenever it is possible. When it is not possible to draw up exclusive licensing contracts, the choice between non-exclusive licensing and independent selling depends on the cost position of the innovator. It should be pointed out, however, that in those cases the innovator should always verify whether or not a special type of licensing agreement (L^{r^*}) can be devised which enables the innovator to effectively replicate an exclusive license. Indeed, under specific conditions, an optimal royalty rate r^* can be set which enables the innovator to credibly, and costlessly commit not to use his own innovation. Since such an agreement replicates an exclusive license, it is preferable, whenever it is possible, to nonexclusive licensing or independent selling. Finally, if the relative cost disadvantage ratio becomes very large, the innovator is no longer able to compete with the licensee, ensuring that the license is *de facto* exclusive.

The above discussion clearly illustrates a fundamental drawback of a strategy which is narrowly focused on pursuing competitive advantage in product markets. Access to scarce resources is frequently believed to be a sufficient reason for pursuing a cost leadership or differentiation strategy. While a strong product market position might be achieved, our analysis shows that captive use will frequently fail to capture the full rent potential of strategic resources. The optimal deployment strategy is determined by the interplay of three concerns: achieving cost efficiency, ensuring coordinated pricing, and mitigating competition. In this light, we better understand GE's drive to leverage its core

industrial capabilities in non-traditional ways, and why GE's efforts are "being closely watched (...) as a pattern for the refashioning of an industrial company in the postindustrial economy" (*Business Week,* Oct. 28, 1996, pp. 43-44).

The model presented in this paper can be extended in several ways. First, while the model involves only two firms, it can easily be extended to three or more firms. The main results carry through without modification. Two clarifications are necessary, however. When exclusive licensing is possible, a high-cost innovator should license the technology exclusively to only *one* firm, the one with the lowest cost position in the production of the basic product. Furthermore, captive use is optimal if and only if the innovator has *the lowest* cost position of all firms in the market. Thus, for example, if the innovator is the *second* most efficient firm, captive use is no longer optimal. In fact, all firms which are not the most cost-efficient producer in their industries should choose licensing or independent selling. This result indicates that captive use is very often *not* the optimal deployment option.

Second, even tough our model captures cost differences and competitive interaction, it does not take into account a number of important factors that have been identified in the literature. Specifically, this work could be enriched by incorporating additional insights from the Transaction Cost perspective (e.g., Williamson, 1975; Teece, 1987; Hill, 1992). For example, there may be uncertainty about the value of the technology, which could make licensing more problematic. Furthermore, it may be difficult to license a technology without diffusing the general knowledge underlying the technology to be transferred. This may allow the licensee to improve upon the licensed technology, or to apply it to products that it was not licensed for. If these types of costs are significant, they may create a further

incentive for a high-cost innovator to sell the innovation independently to consumers instead of licensing it.

Finally, an important extension of the paper would be to formally model a broader range of collaborative arrangements (e.g., exclusive sourcing, joint-ventures). Notice, however, that these extensions can only further restrict the domain of optimality of captive use, reinforcing a key conclusion of this paper: captive use is not, in general, the optimal deployment option.

Appendix A

Assume that firm 2 uses the innovation captively. For a given pair of equilibrium prices (p_{B1}^{cu},p_{E2}^{cu}), firm 2's equilibrium profit is given by

$$\Pi_2^{cu} = D_E(p_{E2}^{cu}, p_{B1}^{cu}) \cdot (p_{E2}^{cu} - c_2).$$

Consider now that firm 2 sells the innovation independently to consumers. Assume that, for $p_{B1}=p_{B1}^{is}$, firm 2 sets a price $p'_y=p_{E2}^{cu}-c_2$. Its profit is then given by

$$\Pi_2' = D_E(p_{B1}^{is} + p_y', p_{B1}^{is}) \cdot p_y' =$$
$$= D_E(p_{E2}^{cu} + p_{B1}^{is} - c_2, p_{B1}^{is}) \cdot (p_{E2}^{cu} - c_2).$$

To compare Π_2^{cu} and Π_2', distinguish three cases: $p_{B1}^{cu}=p_{B1}^{is}$, $p_{B1}^{cu}>p_{B1}^{is}$, and $p_{B1}^{cu}<p_{B1}^{is}$.

(a) $p_{B1}^{cu}=p_{B1}^{is}$. In this case, $\Pi_2^{cu}\leq\Pi_2'$ and $\Pi_2^{cu}\leq\Pi_2^{is}$, because $p_{B1}^{is}\leq c_2$. Notice that if $p_{B1}^{cu}=p_{B1}^{is}=c_2$, then $p_y^{is}=p_y'$ and $\Pi_2^{cu}=\Pi_2'=\Pi_2^{is}$.

(b) $p_{B1}^{cu}<p_{B1}^{is}$. In this case, $\Pi_2^{cu}<\Pi_2'$ and $\Pi_2^{cu}<\Pi_2^{is}$, because $D_{EB}>0$.

(c) $p_{B1}^{cu}>p_{B1}^{is}$. In this case, since $p_{B1}^{is}<p_{B1}^{cu}\leq c_2$, we know that

$$c_2 - p_{B1}^{is} \geq p_{B1}^{cu} - p_{B1}^{is} > 0.$$

We also know that $|D_{EE}| \geq |D_{EB}|$. Therefore, $\Pi_2^{cu}\leq\Pi_2'$ and $\Pi_2^{cu}\leq\Pi_2^{is}$.
One can easily verify that $\Pi_2^{cu}<\Pi_2^{is}$, except if (1) $p_{B1}^{cu}=p_{B1}^{is}=c_2$ or if (2) $p_{B1}^{is}<p_{B1}^{cu}=c_2$ and $|D_{EE}|=|D_{EB}|$. In these two cases, $\Pi_2^{cu}=\Pi_2^{is}$. ■

Appendix B

We first show sufficiency. The proof of sufficiency consists of two steps.
(i) We first show that, for (1) $|D_{EE}| \geq |D_{BE}|$, (2) $p_{B1}^{el}=c_2$ and (3) $p_{B1}^{r^*}=c_2$, if licensing occurs and $r=r^*=p_{E1}^{el}-c_2$, firm 1 can charge $p_{B1}=p_{B1}^{el}=c_2$ and $p_{E1}=p_{E1}^{el}$ without facing competition from firm 2 in x_E. Under these conditions, firm 1 can charge the pair of prices $p_{B1}=p_{B1}^{el}=c_2$ and $p_{E1}=p_{E1}^{el}$ without facing competition of firm 2 in x_E, if and only if

$$RP = (p_{E1}^{el} - c_2) \cdot D_E(p_{E1}^{el}, p_{B1}^{el}) \geq \Pi_2^E = (p_{E2} - c_2) \cdot D_E(p_{E2}, p_{B1}^{el}),$$

$\forall$ $p_{E2}<p_{E1}^{el}$. Since $(p_E-c_2)\cdot D_E(p_E,p_B)$ is, by assumption, differentiable and concave in p_E, $RP\geq\Pi_2^E$ if and only if

$$D_E(p_{E1}^{el}, c_2) + D_{EE} \cdot (p_{E1}^{el} - c_2) \geq 0.$$

This condition implies that by competing in the enhanced product, with a price p_{E2} slightly lower than p_{E1}^{el}, firm 2 (weakly) decreases its profit.

Since, by assumption, $p_{B1}^{el}=c_2$, p_{E1}^{el} is determined by the first-order condition

$$\frac{\partial \Pi_{1+2}}{\partial p_{E1}} = D_E(p_{E1}^{el},c_2)+D_{EE}\cdot(p_{E1}^{el}-c_1)+D_{BE}\cdot(c_2-c_1)=0.$$

This condition can be written as

$$D_E(p_{E1}^{el},c_2)+D_{EE}\cdot(p_{E1}^{el}-c_2)+D_{EE}\cdot(c_2-c_1)+D_{BE}\cdot(c_2-c_1)=0.$$

For $|D_{EE}|\geq|D_{BE}|$, this implies

$$D_E(p_{E1}^{el},c_2)+D_{EE}\cdot(p_{E1}^{el}-c_2)\geq 0.$$

(ii) We now verify that, in fact, $p_{E1}^{r^*}=p_{E1}^{el}$. In equilibrium firm 1 sets the price p_{E1} that maximizes

$$\Pi_1 = D_E(p_{E1},c_2)\cdot(p_{E1}-c_1-r^*)+D_B(c_2,p_{E1})\cdot(c_2-c_1)$$

s.t. $p_{E1}\leq p_{E1}^{el}=c_2+r^*$.

Ignore for a moment the restriction on p_{E1}. For $p_{B1}^{r^*}=p_{B1}^{el}=c_2$, p_{E1} is given by the corresponding first-order condition

$$\frac{\partial \Pi_1}{\partial p_{E1}} = D_{EE}\cdot(p_{E1}-c_1-r^*)+D_E(p_{E1},c_2)+D_{BE}\cdot(c_2-c_1)=0.$$

From the first-order condition it is easy to verify that without the restriction on p_{E1}, for any royalty $r>0$, and in particular for $r=r^*$, firm 1 would charge a price $p_{E1}>p_{E1}^{el}$. Consider now the restriction $p_{E1}\leq p_{E1}^{el}$. Due to the concavity of firm 1's profit on p_{E1}, the best firm 1 can do is to set $p_{E1}^{r^*}=p_{E1}^{el}$.

The proof of necessity is straightforward and is therefore simply sketched here. First relax the assumption $p_{B1}^{el}=c_2$. If $p_{B1}^{el}<c_2$, two things may happen: (a) $p_{B1}^{r^*}=c_2$ and (b) $p_{B1}^{r^*}<c_2$. In case (a), we have $p_{B1}^{r^*}\neq p_{B1}^{el}$. In case (b), one can easily verify by inspection of the first-order conditions that $p_{B1}^{r^*}<p_{B1}^{el}$. In both cases licensing introduces a distortion in the pricing decisions of the licensee. A similar argument can be developed for the assumption $p_{B1}^{r^*}=c_2$. Clearly, if $|D_{EE}|<|D_{BE}|$, 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_{E1}^{el}. For $p_{E1}=p_{E1}^{el}$, firm 2 has the incentive to produce x_E. ■

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Notes

[1] For discussions on the importance and the limitations of the use of game-theoretic modeling in the Strategic Management field see also Shapiro (1989), Camerer (1991), Saloner (1991), Porter (1991), and Rumelt, Schendel and Teece (1991).

[2] Following the Industrial Organization literature on vertical differentiation (e.g., Gabszewicz and Thisse, 1979; Shaked and Sutton, 1982), firm A has a vertical differentiation advantage over firm B if all consumers prefer the product of firm A to the product of firm B when both products are offered at the same price.

[3] There are quality-improving innovations which do not consist of complementary products and services and, therefore, cannot be sold independently to consumers. For example, a new engine or a new rear suspension for cars, or a better laser printer engine. In such cases, captive use and the engagement in collaborative agreements with other firms are the only possible uses of the innovation.

[4] The Industrial Organization literature on technology transfer to competitors through licensing discusses the incentives a firm with a new process or product innovation may have to license it to a competitor (e.g., Salant, 1984; Gallini and Winter, 1985; Katz and Shapiro, 1985; Farrell and Gallini, 1986). This paper extends this literature by focusing on quality-improving innovations and by comparing captive use, licensing and independent selling.

[5] In studying independent selling, we assume that the add-on (or the upgrade) is compatible with the basic product of both firms. However, in many situations the innovator may be able to make the add-on or upgrade compatible with the basic product of one firm and incompatible with the basic product of the other firm. As the compatibility decision has been studied elsewhere (e.g., Matutes and Regibeau, 1988; Economides, 1989), we do not consider these situations.

[6] Since, in this model, we only consider two firms, firm 1 and firm 2, the *joint profits* of the two firms correspond to *industry profits*. As we will see below, the model can be extended to three or more firms, without affecting the main results.

[7] To ensure the existence of such an equilibrium, we assume that, for $p_{B1} \in [c_1, c_2]$ and $p_{E2} > c_2$, the profit function of firm 1 is concave in p_{B1} and the profit function of firm 2 is concave in p_{E2}.

[8] For any $p_y > 0$, p_E $(\equiv p_B + p_y) > p_B$, and, consequently, we may restrict our attention to situations where D_B and D_E have the desired properties mentioned above. To ensure the existence of an equilibrium of this pricing game, we assume that, for $p_{B1} \in [c_1, c_2]$ and $p_y > 0$, the profit function of firm 1 is concave in p_{B1} and the profit function of firm 2 is concave in p_y.

[9] A formal proof of this result is given in Appendix A. From Appendix A it can be seen that the innovator's profits are strictly greater under independent selling than under captive use except if (1) $p_{B1}^{is} = p_{B1}^{cu} = c_2$ or if (2) $p_{B1}^{is} < p_{B1}^{cu} = c_2$ and $|D_{EE}| = |D_{EB}|$. In this two cases $\Pi_2^{cu} = \Pi_2^{is}$. For ease of exposition, we focus on the general case, where the innovator's profits are strictly greater under independent selling than under captive use.

[10] Π_{1+2} is assumed to be concave in both arguments with a maximum at (p_{B1}^*, p_{E1}^*) .

[11] From inspection of the first-order conditions it can easily be verified that, in fact, independent selling leads to sub-optimal pricing. As a result, $\Pi_{1+2}^{el} > \Pi_{1+2}^{is}$.

[12] Exclusive licensing has two advantages over captive use: *increased cost-efficiency* and *coordinated pricing of the basic and the enhanced products*. Exclusive licensing increases efficiency because the enhanced product is produced at a lower cost by firm 1 than by firm 2. Exclusive licensing involves coordinated pricing because firm 1 supplies both the basic product and the enhanced product.

[13] Notice that in addition to *increased cost-efficiency* and *coordinated pricing of x_B and x_E*, nonexclusive licensing has a third effect relative to captive use: it *introduces competition in x_E*. Under nonexclusive licensing, two firms are able to produce the enhanced product, the innovator and the licensee. Therefore, the licensee is constrained in the price it charges for the enhanced product by the innovator.

[14] Under nonexclusive licensing, a royalty $r^*=p_{E1}^{el}-c_2$ eliminates the innovator's incentive to compete in the enhanced product for $p_{B1}=p_{B1}^{el}$ and $p_{E1}=p_{E1}^{el}$, without introducing any distortion in the pricing decisions of firm 1, if and only if (1) $|D_{EE}|\geq|D_{BE}|$, (2) $p_{B1}^{el}=c_2$ and (3) $p_{B1}^{r^*}=c_2$ (the superscripts "r^*" indicate equilibrium under nonexclusive licensing with $r=r^*$). This result is shown in Appendix B. Under these conditions, the optimal licensing contract includes a royalty $r=r^*$. For example, when consumers' preferences are described by $U=\theta q-p$ if the consumer consumes one unit of quality q and pays price p, and by 0 otherwise (where the parameter θ of taste for quality is uniformly distributed between $\theta'\geq 0$ and $\theta''=\theta'+1$), a royalty r^* eliminates the innovator's incentive to compete in the enhanced product for $p_{B1}=p_{B1}^{el}$ and $p_{E1}=p_{E1}^{el}$, without introducing any distortion in the pricing decisions of firm 1. This preferences structure was first proposed by Gabszewicz and Thisse (1979) and Shaked and Sutton (1982) (see also Tirole, 1988, pp. 296).

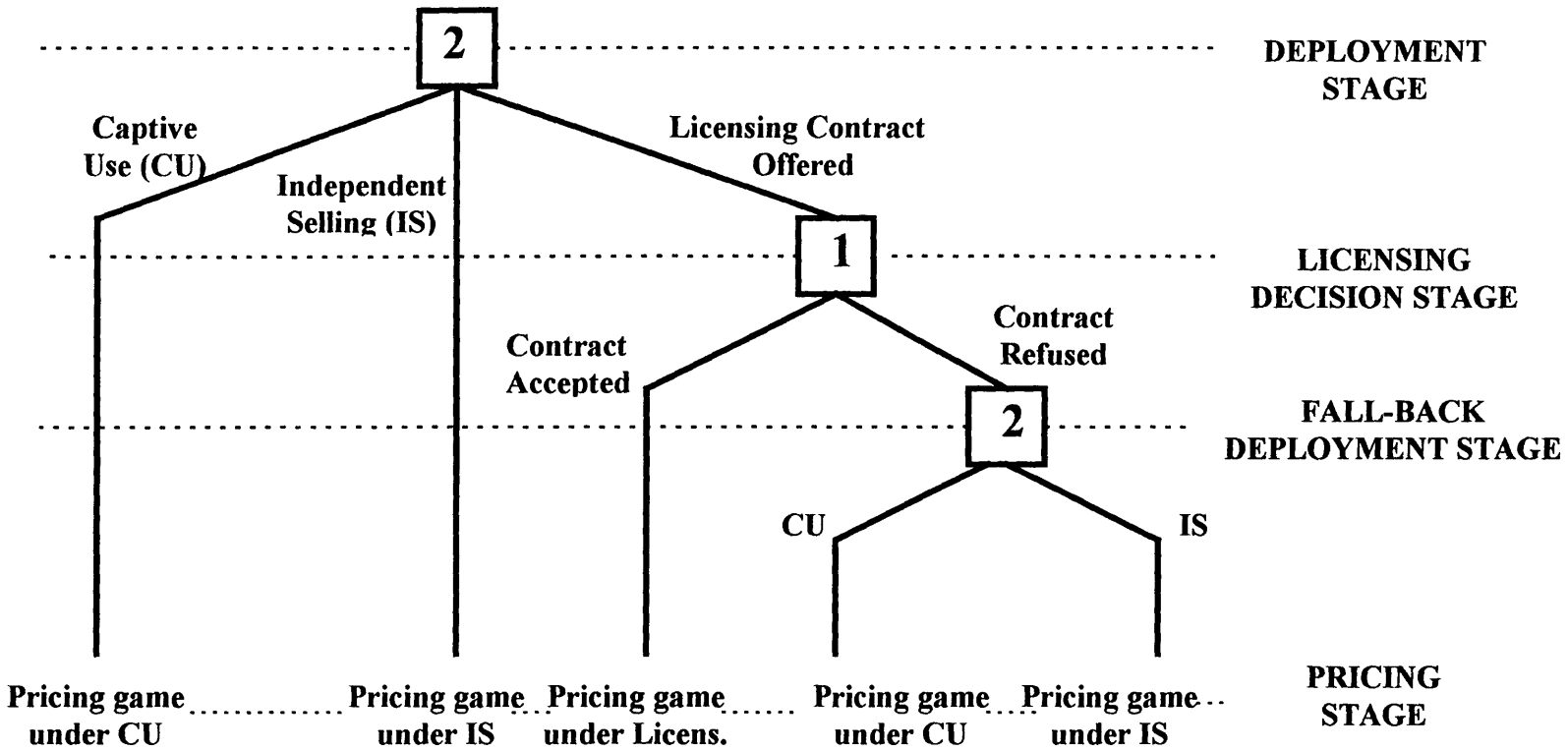

Figure 1: Structure of the Game

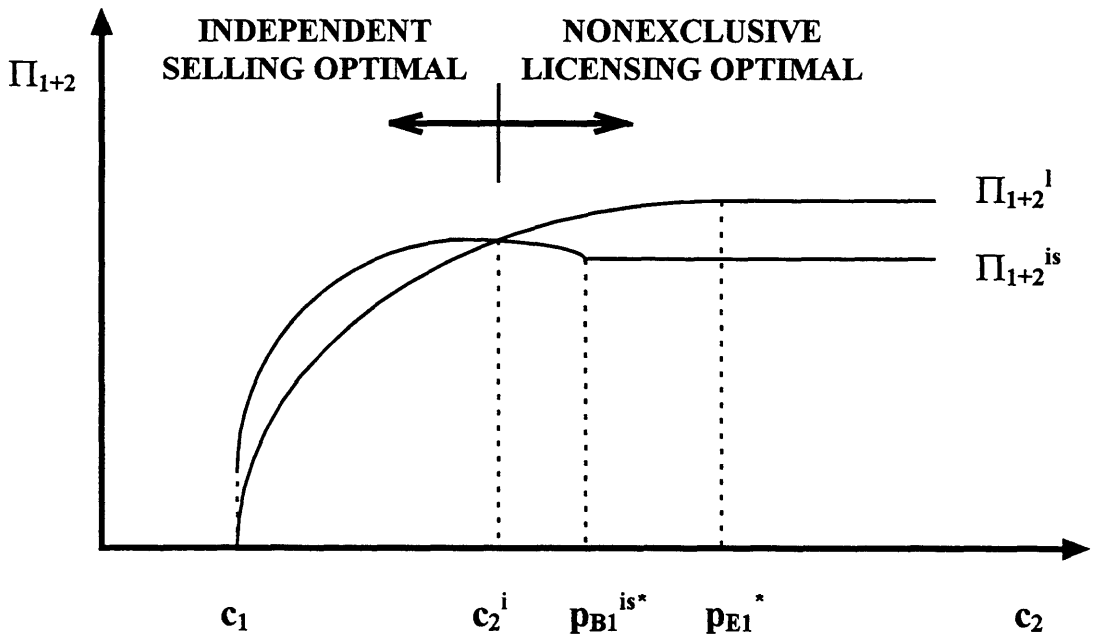

Figure 2: Nonexclusive Licensing vs. Independent Selling

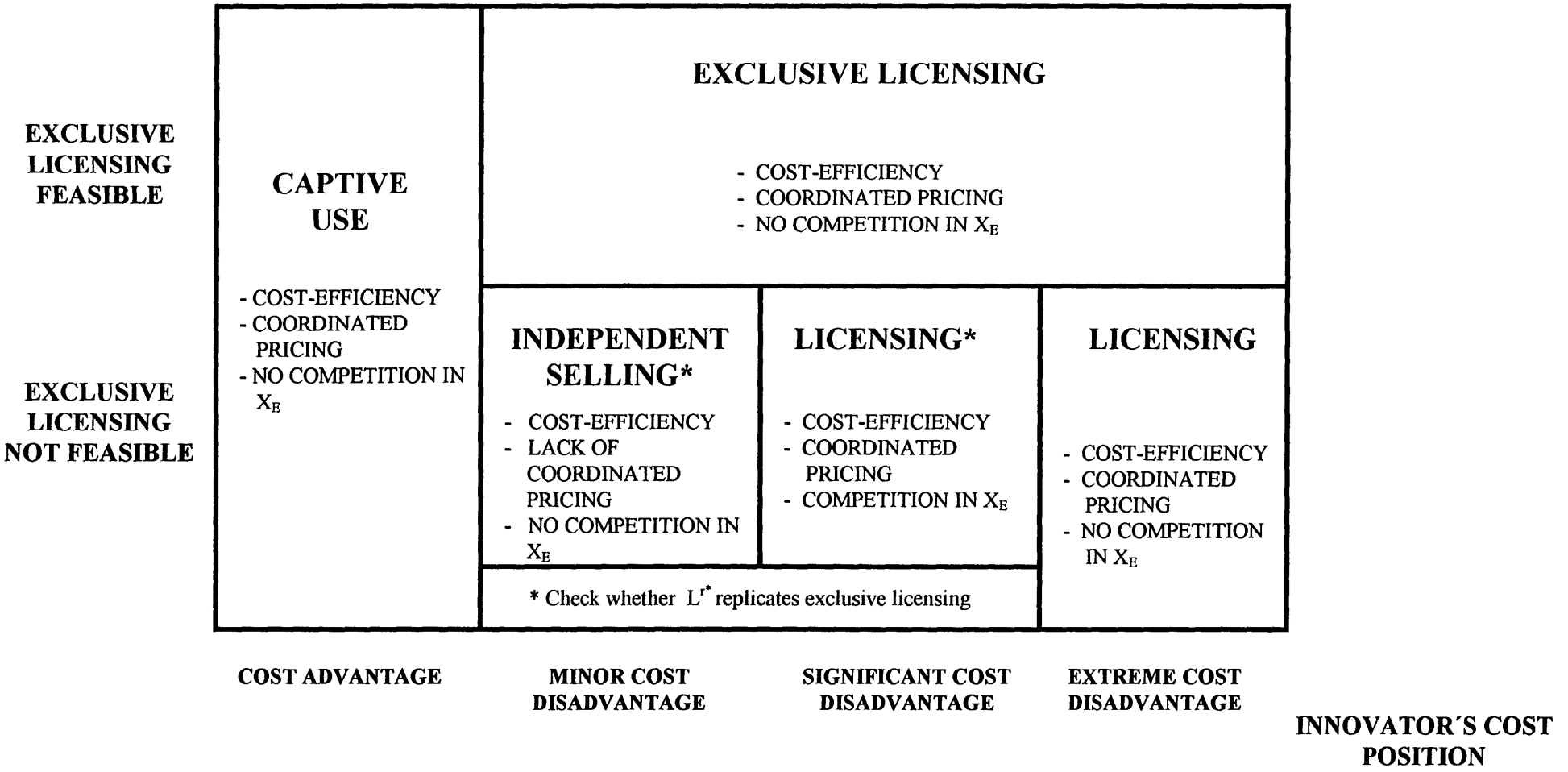

Figure 3: Optimal Deployment Strategies