"MONOPOLY INCENTIVES TO LICENSE A PRODUCT WITH NETWORK EXTERNALITIES"

by

Michael KENDE*

93/74/EPS

* Assistant Professor of Economics, at INSEAD Boulevard de Constance, 77305 Fontainebleau, Cedex, France.

Monopoly Incentives to License a Product with Network Externalities

Michael Kende *

INSEAD, Fontainebleau, France

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Abstract

This paper shows the effects on profits and consumer surplus of a monopolist licensing a good from which consumers derive network externalities. Licensing a proprietary technology increases the output and thus the network of the licensed good. By credibly committing to licensing in the future, the monopolist increases current sales and profits at the expense of future monopoly profits. The increase in current profits can outweigh the loss of future profits. If a credible commitment to future licensing is not possible, in some cases licensing beginning in the current period can also increase the licensor's profits. In all cases licensing, by increasing the size of the network of compatible goods, increases consumer surplus.

* *Correspondence to:* Michael Kende, Assistant Professor of Economics, INSEAD, Fontainebleau 77305, France.
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1 Introduction

A product is said to have network externalities when a user's utility increases, the more users there are of compatible products. A classic example of such a product is the telephone, for which utility is wholly dependant on the size of the network of users with compatible phones. This is an extreme example, because there are no stand-alone benefits of having a telephone. A less extreme example is the personal computer, which provides both stand-alone benefits as well as network benefits. Many of the benefits of a computer are derived from being able to communicate with others and having a wide variety of software to choose from. The more users there are of compatible computers, the greater are these benefits.

This paper explores the conditions under which, in a dynamic setting, a monopoly supplier of a good with network externalities can increase profits by creating competition. The monopolist creates competition by licensing the product to at least one other firm. The resulting competition increases the total output of the product. In the absence of network externalities this decreases total profits from the product. With network externalities the increased output makes the product more attractive, and if the network externalities are strong enough this can increase profits. In addition, consumer surplus rises with increased competition, as would be expected.

An example of a product where this type of strategy could be applicable is the new generation of videophones. This is a product which adds video to a phone call over standard telephone lines. Like its audio predecessor, the videophone delivers all benefits via network effects. This paper argues that profits can be increased by licensing proprietary technology to other firms. A British firm, GEC-Marconi has developed a videophone and seems to be pursuing such a strategy, having licensed British Telecom, Deutsche Bundespost Telekom, and Amstrad among others.[1] This strategy should help the GEC-Marconi technology become the standard in Europe while increasing the profits of GEC-Marconi. In the U.S. market the GEC-Marconi standard faces a major domestic competitor, AT&T, which has also developed a videophone. Whether this licensing strategy could help GEC-Marconi overcome AT&T's advantage in the U.S. market is addressed in a related paper, Kende (1992).

Section 2 contains a description of recent literature concerned with the issues raised here. Section 3 contains a dynamic model of sales of a product for which users enjoy network externalities. Section 4 explores the effects of a firm licensing its proprietary technology by comparing equilibria with and without licensing.

2 Literature Review

There is a large literature concerning network externalities, most of which is concerned with the results of competition between firms producing similar, but incompatible, products. In addition, there are examples in the literature where creating competition is a strategic policy for a monopolist. This paper combines the literatures by studying the incentives of a firm to create competitors producing a compatible product if there are network externalities.

The literature on network externalities has as its starting point two or more firms producing, or capable of producing, a given product. The existence of network externalities affects competition because consumers must consider not only the current network size, but also future sales, when

[1] *Far Eastern Economic Review*, June 4, 1992, p. 39.

making their purchase decision. Katz and Shapiro (1985, 1986a, 1986b) study the compatibility decision of the firms producing the product, while Farrell and Saloner (1985, 1986) study the adoption decision of consumers faced with incompatible products. This paper studies the decision of a monopolist to create competitors producing compatible products.

There is a separate literature analyzing strategic incentives to license proprietary technology. In the standard models, a monopolist has no incentive to license because monopoly profits are always at least as high as total duopoly profits. Papers by Farrell and Gallini (1986) and Shepard (1987) explore incentives for monopolists to license proprietary technology when contracts are incomplete. Licensing, by creating competition, is a credible commitment to either high quality or low prices. This commitment is necessary to induce potential consumers to sink setup costs without fear of *ex post* appropriation by the monopolist. In this paper the incentive to license is to commit to increasing the network size so that consumers are assured of being in a large (current or future) network.

3 Model

In this model there is assumed to be a firm with a monopoly in a particular good from which consumers derive network externalities. In order to include consumers' expectations of future network size, a dynamic model is used. In period zero the monopolist decides whether to license, and if so sets and announces the licensing parameters. In both periods one and two there is production and consumption. Within each of these periods the consumers observe the output level before buying. First-period consumers decide whether or not to purchase based on current output and expectations of second-period output. Second-period consumers observe both the existing network size as well as current output when making their purchase decision. The model is solved backwards so that the resulting equilibrium is subgame perfect.

3.1 Demand

There is assumed to be one cohort of consumers in each period. Each cohort can only consume in their own respective period. The size of each cohort is normalized to one. In order to simplify the model, assume that this is not a product for which network externalities depend on the future availability of complementary goods such as pre-recorded tapes or computer software. Finally, the good is assumed to be durable and does not depreciate.

The demand curve for the product is derived as in Kende (1992), based on Katz and Shapiro (1985). Let the willingness to pay of the consumers equal r, where $r \sim \mathrm{U}(0,1)$. The hedonic price of the good is defined to be the price net of the network externalities effect. For period 2 this is:

$$\phi_2 = p_2 - nQ_1 - nQ_2. \tag{1}$$

where Q_t gives the total sales at time t, $t = 1,2$. If the monopolist doesn't license then Q_t simply equals the monopoly output, and if there are k_t symmetric licensees (including the original monopolist) at time t, each producing q_t, then $Q_t = k_t q_t$. The level of network externalities is represented by n, with the assumption that $0 < n < 1$. The network externalities function is assumed to be linear in order to make the model tractable.

Consumers purchase as long as their willingness to pay is at least as large as the hedonic price. Given the uniform distribution of r, $P(r \geq \phi_2) = 1 - \phi_2$. Given unit demands, $1 - \phi_2 = Q_2$, and the demand curve is:

$$p_2 = 1 - Q_2 + nQ_1 + nQ_2 \tag{2}$$

using equation (1) from above. Demand in the first period can be derived in a similar fashion:

$$p_1 = 1 - Q_1 + 2nQ_1 + nQ_2^e. \tag{3}$$

Note that there is no discounting, so that first-period buyers derive network externalities $2nQ_1$ from first-period sales of the good they purchase plus nQ_2^e from the expected second-period purchases of the same good.

3.2 Profits

The firm faces a fixed cost F of developing a standard, and a constant marginal cost c_o of production. The gross profit function for the monopolist or a representative licensee in each period is:

$$\begin{aligned} \pi_1 &= q_1(p_1 - c_o) & (4) \\ \pi_2 &= q_2(p_2 - c_o). & (5) \end{aligned}$$

If there is no licensing, q_t is the monopoly level of output, otherwise q_t equals the output of any of the k symmetric licensees. The total profit in each period is Π_t, where this either equals monopoly profits or the total profits of the licensees, $k_t\pi_t$. Total net profits are

$$\Pi = \Pi_1 + \Pi_2 - F. \tag{6}$$

Note that there is assumed to be no discounting of profits.

3.3 Welfare

Consumer surplus is derived as in Katz and Shapiro (1985). The demand curve in period 2, from equation (2), is $Q_2 = 1 - p_2 + nQ_1 + nQ_2$. From equation (1), $Q_2 = 1 - \phi_2$. Consumer net surplus in period two is thus:

$$CS_2(Q_2) = \int_{1-Q_2}^{1} (1 - \phi_2) d\phi_2 = \frac{Q_2^2}{2}, \tag{7}$$

and in period one is $CS_1(Q_1) = \frac{Q_1^2}{2}$. Thus consumer surplus in any period is simply a function of the total quantity sold in the market that period. The greater the level of network externalities, n, the more is sold, and the greater the consumer surplus. For the purpose of computing welfare, profits are simply going to be net industry profits, Π. Welfare is the sum of consumer surplus and profit:

$$W(Q_1, Q_2) = \Pi_1 + \Pi_2 - F + CS_1(Q_1) + CS_2(Q_2). \tag{8}$$

4 Equilibria

In this section the market outcome of the above model is determined both when there is licensing and when there is no licensing. If there is no licensing, the monopolist simply maximizes profits over the two periods, taking into account the effect that first-period sales have on second-period profits due to the network externalities. If the monopolist chooses to license the standard, the licensees are assumed to be symmetric and compete in Cournot quantities. First-period consumers internalize the effect on output of credible future licensing when making their forecasts of second-period network size. The results of licensing versus not licensing are compared by solving the respective equilibria and plugging in values for the parameters. The equilibria are compared in terms of both relative profits and consumer surplus.

4.1 Equilibrium without Licensing

4.1.1 Period 2

In period two the monopolist maximizes second-period profit in second-period output to determine the optimal level of second-period output as a function of first-period output:

$$\text{Max}_{q_2}\pi_2 \quad = \quad q_2(1 - q_2 + nq_1 + nq_2 - c_o).$$

Solving the first-order condition gives:

$$q_2(q_1) = \frac{1 + nq_1 - c_o}{2(1-n)}. \tag{9}$$

4.1.2 Period 1

Consumers are rational, so $q_2^e = q_2(q_1)$. Since first-period production has an effect on second-period profits via the network externalities, in the first period the monopolist maximizes total profit in first-period sales:

$$\text{Max}_{q_1}\pi = q_1(1 - q_1 + 2nq_1 + nq_2(q_1) - c_o) + q_2(q_1)(1 - q_2(q_1) + nq_1 + nq_2(q_1) - c_o).$$

The result of this maximization is:

$$q_1(n, c_o) \;=\; \frac{2(1-c_o)}{(5n-2)(n-2)}.$$

Substituting into (9) gives:

$$q_2(n, c_o) \;=\; \frac{(1-c_o)(4-10n+5n^2)}{2(1-n)(5n-2)(n-2)}.$$

Note that at $n = .4$ the denominator of $q_1(n, c_o)$ and $q_2(n, c_o)$ equals 0. The second-order condition is not strictly satisfied for $n \geq .4$. Therefore, the network externalities are restricted to $n < .4$.

4.1.3 Period 0

The monopolist enters the market if

$$\pi = \pi_1(n, c_o) + \pi_2(n, c_o) - F \geq 0.$$

4.1.4 Results

The results show that in equilibrium first-period output is greater than second-period output for any level of network externality (n) and cost (c_o). This is because the monopolist sets a relatively low price in the first period in order to be able to exploit the benefits of a larger network in the second period. As n increases, sales and profits both rise because consumers are more willing to buy, the greater the benefits that they enjoy. Finally, consumer surplus also increases with n, because consumers get more benefits from a larger network.[2] Table 1 illustrates these equilibrium results for sample values of the parameters. The first column of each of the three groups is for the no-licensing case.

4.2 Licensing

In this section the monopolist licenses its technology to other firms as a strategic move to increase the network of compatible goods. It is shown that in a dynamic setting with network externalities licensing is a profitable strategy under certain conditions. Consumer surplus also increases, so

[2]These results, that $\frac{\partial \pi_t}{\partial n}$, $\frac{\partial q_t}{\partial n}$, and $\frac{\partial CS_t}{\partial n}$ are greater than zero, hold for all values of n and c_o where there are no corner solutions.

total welfare can increase due to licensing.

A monopolist selling a good with network externalities would like to convince consumers that the network size will increase rapidly in the future. Katz and Shapiro (1986b) note that, in the model presented above, a monopolist cannot precommit to producing a high output in the second-period, because of a credibility problem which is the opposite of that of the durable goods monopolist (Coase, 1972). In the durable goods monopolist case, the monopolist cannot credibly convince consumers that it will keep prices high in the future, resulting in lower current sales in anticipation of lower future prices. With network externalities present the monopolist has the problem that it cannot credibly convince current consumers that it will keep *output* high in the future. In the framework presented here, the monopolist would like to commit to high output in period two in order to convince period-one consumers that the ultimate network that they will belong to will be large. However, this is a time-inconsistent strategy, because if period-one consumers acted on the monopolist's promise of a large second-period output, it would no longer be in the best interest of the monopolist to actually produce a high output in the second period. Rational consumers foresee this, and in the first period would not expect the level of future sales that the monopolist claims will be produced.

One way for the monopolist to commit to increasing the second-period network size is by licensing the good in period zero for production in the second period. Licensing increases the total output of the licensed product when the licensees engage in symmetric Cournot competition. The amount produced is a positive function of the number of licensees. Licensing by the monopolist could only be profitable if there are network externalities and a dynamic setting. If there is only one period, even with network externalities present, profits are greater for a monopolist than the total profit of two or more licensees engaged in Cournot competition.[3] If there are two periods, the presence of network externalities provides an interdependency between the periods. Without network externalities each period is a separate game, and once again a monopoly can do at least as well as two licensees. With the network externalities in a two period game, increased second-period expected sales have a positive effect on first-period sales and profits, and licensing can be a profitable strategy for a monopolist.

The monopolist can make the commitment to licensing in the future credible in a number of ways. The simplest way to make the commitment credible is if the firm is able to enter into a legally binding licensing contract. If this is not possible commitment may be achieved through reputation effects. The firm may frequently introduce new products with patentable formats and plan to use the strategy presented here.[4] This firm can grant licenses for second-period production before the first period and consumers know it is not in the long-run interests of the firm to revoke them. A final way may be to grant the licensee permission in period zero to begin producing as soon as possible, but hold back some technical information so that the licensee spends period one reverse-engineering the product before being able to produce in period two. However credibility is achieved, the license agreement must be made known to first-period consumers in order to have the desired effect on the outcome.

[3]This is because the best that two or more licensees can do is collude and produce the monopoly level of output, earning the same total profit as a monopolist would earn. If the licensees compete in a non-collusive fashion such as Cournot, the total sales are greater than a monopolist's sales would be, and the total profits are lower.

[4]An example of such a firm is Sony, which has pioneered various formats in both video cassette recorders as well as digital audio products.

If a credible commitment to future licensing is not possible, it may be profitable to grant a license in period zero allowing production in both periods one and two. It is assumed that having a licensee producing in the first period is a credible commitment to having a licensee in the second period. This may be true because it is more difficult legally to revoke a license if the licensee has already invested in equipment and begun producing. Licensing for both periods is only profitable for very high levels of network externalities. Licensing for the first period increases first-period sales at the expense of profits. However, with high enough network externalities the output becomes so large that second-period profits increase enough to compensate for first-period losses. Licensing for both periods is a second-best solution because even when it is profitable, licensing for the second period only is still the dominant strategy.

4.2.1 Equilibrium with Licensing

In this section the equilibria for licensing only for future production, or for both current and future production, are explored. In both cases the model proceeds as follows. In period zero the monopolist chooses and announces the licensing parameters for production in the next two periods. These parameters are k_t, the number of licensees, and L_t, the license fee, which is a fixed fee instead of a royalty due to the standard monitoring problems. It is assumed that the licensor is able to appropriate all rent from the licensees with the license fee. In any period when there is licensing the monopolist is either one of the k_t symmetric licensees or acts as an independent lab, not producing but simply collecting license fees.

The first case is where the monopolist grants k_2 licenses in period zero for second-period production in order to convince first-period consumers that the future network will be large. It is assumed that these licenses cannot be revoked by the monopolist after the first period. All of the monopolist's first-period output is compatible with the licensees' second-period output and thus is a part of the network.

The second case is where the monopolist is not able to credibly commit to licensing for future production. In this case the monopolist may be able to increase profits by licensing in period zero for production in both periods. The license fee, L_t, can be different in each period, and equals the level of profits of the licensee. It is assumed the the number of licensees, k, is the same in both periods.

4.2.2 Period 2

The analysis of the second period is independent of whether or not there was licensing in the first period because there are second-period licensees in either case. In period two each symmetric licensee maximizes profit:

$$\mathrm{Max}_{q_2} \pi_2 = q_2(1 - Q_2 + nQ_1 + nQ_2 - c_o).$$

Solving the maximization problem results in:

$$q_2(Q_1) = \frac{1 + nQ_1 - c_o}{(k_2 + 1)(1 - n)} \tag{10}$$

and $Q_2(Q_1) = k_2 q_2(Q_1)$. If there is licensing in both periods, $k_2 = k$.

4.2.3 Period 1

Rational consumers base their expectations on the above calculations, so $Q_2^e = Q_2(Q_1)$.

If there is only licensing for period two, then in period one the licensor chooses output to maximize its first-period profit as well as the sum of all second-period license fees, where $L_2 = \pi_2$:

$$\text{Max}_{q_1}\Pi \;=\; q_1(1 - q_1 + 2nq_1 + nQ_2(q_1) - c_o) + Q_2(q_1)(1 - Q_2(q_1) + nq_1 + nQ_2(q_1) - c_o).$$

The firm solves the first-order condition to determine first-period production, $q_1(n, c_o, k_2)$, and then can solve backwards using (10) for $Q_2(n, c_o, k_2)$.

If there is licensing for first-period as well as second-period production, then each licensee maximizes total profits in first period output:

$$\text{Max}_{q_1}\pi \;=\; q_1(1 - Q_1 + 2nQ_1 + nQ_2(Q_1) - c_o) + q_2(Q_1)(1 - Q_2(Q_1) + nQ_1 + nQ_2(Q_1) - c_o).$$

Once again, each licensee solves its first-order condition to determine first-period production, $q_1(n, c_o, k)$, and then can solve backwards for $q_2(n, c_o, k)$, using (10).

4.2.4 Period 0

In period zero the monopolist determines the profit-maximizing number of licensees and license fees.

If there is only second-period licensing the monopolist determines the profit-maximizing k_2

given the value of n and c_o:

$$\text{Max}_{k_2}\Pi = \pi_1(n, c_o, k_2) + k_2 \cdot \pi_2(n, c_o, k_2)$$

and L_2 equals the profit of the licensee, π_2.

If there is licensing for both periods the monopolist determines k, L_1, and L_2. To determine the profit-maximizing k the monopolist solves the following:

$$\text{Max}_k\Pi = k \cdot \pi_1(n, c_o, k) + k \cdot \pi_2(n, c_o, k).$$

Once again the profit maximizing license fee is simply the profit of the licensee in each period, π_t.

4.2.5 Results

If the network externalities are high enough, it becomes profitable to license to at least one other firm for the second period. Licensing for period two ensures a greater second-period output level, as the licensees engage in Cournot competition. The increased expected network size in period two due to licensing makes the product more attractive in period one, increasing first-period profits. Furthermore, the greater is n, the greater is the increase in first-period profits from the network effects of licensing. The licensor suffers losses in period two when the licensing actually takes effect, however, because Cournot competition results in second-period output which is greater than the monopolist would have produced. When the level of network externalities, n, is greater than .188 the increase in first-period profits outweighs second-period losses, and the strategy of licensing for future production is profitable. Because licensing for future production is time-inconsistent, it is only profitable if consumers and the licensees can be convinced that the licenses cannot be revoked.

If consumers cannot be convinced that a commitment to future licensing is credible, the monopolist could license k firms in period zero where the license is now valid for production in both periods. Licensing for the first period increases output over the monopoly level, and first-period profits for the licensor fall. In the second period there are two opposing effects of licensing on second-period profits: the larger existing first-period network has a positive effect, while the increase in production due to licensing has a negative effect. As n increases the former effect outweighs the latter, and licensing for both periods increases second-period profits. When n is larger than .262 the increase in second-period profits outweighs the loss in first-period profits, and licensing for both periods becomes a profitable strategy. Note that this is only a second-best strategy, because even for these high levels of n it is still more profitable to license only for future production if possible.

Consumer surplus increases for both licensing strategies at all levels of n, because licensing increases output levels, increasing the benefits that consumers derive from being in the network.

The equilibrium values of output, profits, and consumer surplus are given in Table 1 for sample values of the parameters. The first group of results is for a level of the network externalities below the level where any licensing is profitable. The second column of this group shows the case of having two licensees in the second period. Note that first-period sales and profits for the licensor go up because of expectations of higher second-period sales. However, the increase in second-period sales due to licensing lowers second-period profit enough to lower total profits for the licensor so that licensing is not profitable. The second group of results in Table 1 is for a level of network externalities above the cutoff (.188) where second-period licensing is profitable. In this case if $k_2 = 2$ the increase in first-period profits outweighs the second-period losses, and total profits are greater than they would be without licensing.[5]

In the third group of Table 1, n is greater than the minimum level (.262) required for profitable licensing in both periods. The third column of the third group shows that profits increase from both-period licensing at this level of n. However, profits are not as high as with only second-period licensing for these parameter values. The marginal cost was increased to .7 for this example to avoid corner solutions.

Note that consumer surplus is always greater with licensing than it would be without licensing, due to the increased output. In addition, licensing, for any value of n, increases total welfare as the increase in consumer surplus outweighs any losses from licensing (at low levels of n).

5 Conclusions

The results above show the effects on profits of a monopolist licensing a product from which consumers derive network externalities. For a certain range of network externalities, a commitment to licensing in the future is profitable if it can be made credible. If it is not credible, for very high levels of network externalities it can be profitable to license for both current and future

[5]Note that these results are presented without discounting. For any positive discount rate second-period licensing, which increases current profits at the expense of future profits, becomes an even more attractive strategy. As the discount rate increases, the value of n above which licensing is profitable decreases.

production. In the range of network externalities where licensing increases profits, it also increases welfare because consumer surplus also rises.

Licensing may be a profitable strategy for firms introducing a product like the videophone. However, many firms introducing new products are not long-run monopolists but simply first-movers. The strategy presented in this paper may not only increase profits as shown here, but because it entails creating a large initial network, it may have the additional strategic benefit of helping to deter entry by competing formats. An analysis of this would incorporate more traditional aspects of the network externalities literature such as competition between competing formats and adoption decisions of consumers faced with these incompatible formats.

Table 1: Results with variations of licensing.

	n=.1, c=.2			n=.2, c=.2			n=.3, c=.7		
	$k_1 = 1$ $k_2 = 1$	$k_1 = 1$ $k_2 = 2$	$k_1 = 2$ $k_2 = 2$	$k_1 = 1$ $k_2 = 1$	$k_1 = 1$ $k_2 = 2$	$k_1 = 2$ $k_2 = 2$	$k_1 = 1$ $k_2 = 1$	$k_1 = 1$ $k_2 = 2$	$k_1 = 2$ $k_2 = 2$
q_1	.56	.57	.74	.89	.92	1.0	.71	.78	.94
q_2	.48	.63	.65	.61	.82	.83	.37	.51	.55
π_1	.22	.23	.20	.35	.38	.37	.09	.11	.09
π_2	.20	.18	.19	.30	.27	.28	.09	.09	.11
CS	.27	.36	.48	.58	.76	.85	.32	.43	.59
π	.43	.41	.39	.64	.65	.64	.18	.20	.19
W	.70	.78	.87	1.23	1.41	1.49	.50	.63	.78

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