Patent Licenses as Development Contracts: an Alternative View

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Abstract

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This paper argues that patent licenses are partially development contracts. In an environment where innovations accumulate sequentially, manufacturers would take out licenses from an inventor (or a research organization) before the latter has completed and patented his innovations. In so doing, the contract price of the innovations would be lowered. Such contracts require the licensors to make commitments to future development which the licensees will commit to accept. The paper also argues that running royalty rate based on consumer outputs can serve as an inducement mechanism to the committed future development. The alternative view provides several implications on innovation related problems.

Patent Licenses as Development Contracts:
an Alternative View

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Ben T. Yu*

The traditional view of patent licenses concentrates on the "monopoly" effects of existing patents.[1] This paper argues that patent licenses are partially development contracts in which the licensor promises to provide a continuous stream of future innovative services to his licensees.

This proposition arises from the fact that patent licenses usually include the granting of rights to future patents.[2] Out of 70 patent licenses in a public record, 56 contain such clauses.[3] In some, the promise of future improvement is explicit. The following wording is typical:

> (Licensor) agrees fully to advise (Licensee) from time to time of all improvements made or acquired by (Licensor) relative to methods, systems, or equipments covered by this agreement.... (Licensor) also agrees to furnish to Licensee from time to time special engineering services instructions....technical information advice and assistance....according to the special requirements and problems of Licensee and the conditions which may at the time exist.[4]

The potential of such inventive development greatly influences the users' willingness to take out these licenses. In an industry of rapidly changing technology, patent claims are often elusive and are repeatedly challenged in

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court. Potential licensees may thus choose to infringe rather than sign up with a fly-by-night inventive organization, even though the latter temporarily "controls" the industry with a few existing patents. By contrast, a licensor with a continuous interest in development reveals both his comparative advantage in inventing and that future replacement of obsolete technology is likely to come from him. In this case, litigation would be prolonged and a lower chance of winning would make friendly settlement attractive to the licensee. The early years of the automobile industry illustrate how important the licensees view the licensor's inventive potential. From 1903 to 1911, the industry was allegedly controlled by a patent covering "all" gasoline-driven automobiles. The owner of the patent however, was merely a patent holding company which promised no future improvement.[5] It is not surprising that estimated infringement was large and increasing from 1903 to 1907, a period immediately following the first court victory of the patent in 1903 (See Table I, Column 6).

The preceding remark only explains the choice between contracting and infringing. It does not explain why contracting takes the form of precommitment of future development. In other words, why doesn't the licensor issue a new license each time an improvement is made--an arrangement quite plausible under the traditional view? The main reason advanced in this paper is that licensees can <u>lower</u> the royalty rate by shopping among potential inventors and precommitting themselves to use the future research results of the winning licensor-inventor. If licensees were to wait till after future research is patented, they would have to pay close to their maximum demand prices. This form of contract will be called <u>prior contract</u>.

Prior contracting can lower royalty payments under the following general conditions: (a) the goods are collective goods, i. e. those subject to concurrent uses, and free riders can be costlessly excluded, (b) there exist a large number of buyers and potential sellers of the goods, (c) the goods are mutually exclusive in nature, i. e., only one will be chosen, (d) there are competing middlemen between the potential suppliers and final users. These conditions fit quite well in the inventive industries, but may not be found in other industries---thus the argument cannot be applied indiscriminately.

The contract for purchase of license rights to future improvements has its own enforcement mechanism. This paper argues that besides the threat of losing future repetitive purchases, a royalty rate expressed per unit of output utilizing the innovation can encourage future development.[6] This argument is not in conflict with the traditional view which treats a royalty rate as a per unit of output monopoly "tax" giving rise to welfare losses, however.

The chief difficulty of prior contracting is the information cost of finding and evaluating potential inventors. With such cost, users of the innovation may want to see some headstarts. Thus, observed patent licenses are likely to cover both existing patents and future patents. The relative importance of these two classes of patents in patent licenses is an empirical question. This paper also derives several testable propositions to evaluate the extent of prior contracting. They are:

(a) Changes in the market shares of alternative models in an industry would not affect the inventive reward per machine of different models (though the converse is not true).

(b) The licensees who sign up relatively early in the industry should be the larger firms and they should grow faster. This explains why a larger R & D effort should result in higher concentration in the output market (a missing link in the Schumpeterian view).

(c) During a price cut, the running royalty ought to be relatively rigid in comparision with the lump sum charge in patent licenses.

Section I illustrates the logic behind the competitive equilibrium of prior contracting in a world without transaction costs. Section II illustrates how a royalty rate per unit of output can serve as an enforcement mechanism to prior contracting. Section III derives potential testable implications regarding prior contracting.

I.

This section derives a Nash equilibrium in a model consisting of three groups of individuals--inventors, manufacturers, and consumers. Inventors compete in supplying ideas to manufacturers, who compete among themselves in using the new ideas in production for consumers. Such ideas are assumed to be transferable, mutually exclusive collective goods. Thus, only the best idea will be used, and the licensing of the right to use that idea to one manufacturer need not preclude granting the same right to another manufacturer; i. e., licenses can be nonexclusive.[7] Perfect competition among manufacturers in the output market assures that the product price to consumers equals the minimum average cost of production in equilibrium. Competition between manufacturers and inventors is in a different market and it has the added complication of dealing with a collective good. Competitive equilibrium in such a market requires more examination.

We assume numerous identical manufacturers and inventors, each confronting an array of game theoretical strategies in the timing of the contract, negotiation tactics, and searching behavior. The relevant domain from which a strategy would be chosen depends on the type of game played. Three different games will be separately and jointly considered--one among inventors, one among manufacturers, and one between inventor and manufacturer. An equilibrium set of strategies called prior contracts will be shown to emerge, resulting in a royalty covering only the cost of innovation and not inducing a race to invent.[8]

A prior contract for innovation has the following properties: before the act of invention, an inventor quotes a royalty rate to a manufacturer. Once the quoted royalty price is accepted, the manufacturer is committed to pay regardless of subsequent inventive success.[9] Furthermore, the only way a manufacturer can bargain the quoted price downward is by soliciting competitive bids from other inventors. Otherwise, the inventor would commit himself to a rigid quoted price. Such conditions can be characterized by three equilibrium strategies:

P1: Manufacturers search among prospective inventors and commit themselves prior to innovation.

P2: Inventors quote royalty rates prior to innovation and do not rush to invent

P3: The inventor wins bilateral bargaining between him and the individual licensee.

To show that P1, P2, and P3 will emerge from the three games mentioned, we specify the pay-off matrix of the three strategies in comparision with the alternative strategies in each game respectively. The notations used in the payoff matrix are defined in the following ways: Consider a manufacturer who has marginal cost, MC_o, and average cost, AC_o, in producing Q (Figure 1). An innovation is estimated to lower the cost curves to MC_s and AC_s. For simplicity, assume the minimum average cost output, q, remains the same. Without P1 and P2 (but with P3), the manufacturer would have to pay area abcd to the inventor who wins the patent. This is equivalent to charging a royalty of π_o per unit of Q.[10] Competition in the output market dictates that the market price, P_o, equals the minimum of average cost. Thus,

$$P_o = \pi_o + AC_o \tag{1}$$

Traditional analysis also states that the total return to the inventor will be dissipated via rushing to innovate, (Barzel, 1968), i. e.

$$n\ q\ \pi_o = C + \Delta\ C \qquad (2)$$

Where C denotes the most profitable cost to invent the innovation and Δ C represents the extra cost of dissipation by rushing, n is the number of manufacturers.

Now suppose all manufacturers and inventors adopt the strategies of prior contract. A manufacturer searches among potential inventors who each quote a royalty rate.[11] The extent of search and the price quoted by the inventors depend largely on the search cost of the manufacturers and their searching strategies.[12] With zero search cost, an inventor would quote a price ε lower than the lowest price quoted by other inventors. The manufacturer, using this quoted price as a bench mark, would negotiate with other inventors including the ones who had previously quoted him a higher price. This procedure is analytically equivalent to an oral auction. With positive search cost (denoted by S(t), where t is the amount of searches), a manufacturer would stop searching at the point where the marginal gain of search equals marginal cost, S'(t).[13] In this case, the inventor would quote a lower price (a larger ε) because, unlike the previous case, the inventor might not have the opportunity to revise his quoted price once the manufacturer rejects the offer.

The details of the searching precedure are not the main point of this paper. Intuitively, with or without search cost, the royalty rate should fall as search increases, i. e.

$$\pi_t = \pi_o - \sum_{i=1}^{t} \varepsilon_i(S'(i+1),\ v) \qquad (3)$$

π_t is the lowest royalty rate after t searches. $\varepsilon_i(\cdot)$ is the reduction in rate offered by an inventor on the ith search, which depends on the marginal cost of search, S', and the searching strategy, indexed by v.

Equation (3) describes a royalty rate tâtonnement with a stopping rule determined by either the manufacturer or the inventor. The manufacturer would stop when the marginal condition of his searching behavior is satisfied; the inventor would stop at his zero profit condition. If search cost is zero, the marginal condition of the manufacturer is nonbinding, and $t \to \infty$. The cost of the innovation then determines the equilibrium royalty rate, i. e.

$$\pi_{\infty} = \frac{c}{nq} \tag{4}$$

The private gain from searching is short run. If all manufacturers search, competition among them in the product market would reduce the gain by lowering the product price. With a positive search cost, the product price P_t will be determined by a variant of equation (1), i. e.

$$P_t = \pi_t + AC_s + \frac{s(t)}{q} \tag{5}$$

If search cost is zero,

$$P_{\infty} = \frac{c}{nq} + AC_s \tag{6}$$

Equations (3) to (6) describe the consequences of prior contracting. We now examine why such a contract is chosen by comparing alternative strategies in various games:

(1) The manufacturer-manufacturer game

Instead of searching among potential inventors and making commitments with one who will then invent, a manufacturer could wait for inventors to approach him with a finished and patented idea. His gain and cost in choosing between these two strategies depends on what other manufacturers are doing. The pay-off matrix to an individual manufacturer under various possibilities can be specified in Table II.

The sign of each entry in Table II is determined in the following ways: If all manufacturers adopt the same strategies, their net gain will be zero, i. e. substituting (5) and (1) into the expressions of G_{EE} and $G_{\bar{E}\bar{E}}$ respectively yields zero. $G_{E\bar{E}} > 0$ because (a) nonsearching manufacturers have to pay their demand prices, thus keeping the product price up, and (b) an interior solution of searches implies that the reduction in royalty must be greater than the search cost. Also, $G_{\bar{E}E} < 0$ because all other manufacturers have gotton a lower royalty, thus lowering the product price and leaving the individual manufacturer with a negative profit (or a decrease in salvage value of some fixed asset). Therefore, the gain of getting ahead of others and the fear of getting left behind turns search and commit (E) into a dominant strategy, even though at full equilibrium they would all be making zero profit. Condition P1 is thus a derived result.

(2) The inventor-inventor game

The responses of an inventor to the group of searching manufacturers vary: he has the option of cutting his royalty price by ε_{t+1}, or he may refuse to quote or cut his price and instead race to obtain a patent which he can then license. The choice between these two strategies depends on what other inventors would do and how many more manufacturers he thinks would approach him. Denoting n^e as the anticipated number of searchers, the payoff matrix to an individual inventor is shown in Table III.

The sign of each entry in Table III is determined in the following ways: For a given innovation, C, that yields a given optimal firm size, q, G_{QQ} depends on the manufacturer's search cost which affects π_t, and the anticipated number of searching manufacturers, n^e. $G_{Q\bar{Q}}$ depends on whether payment is made prior to or after innovation (see next section). In the former case, $G_{Q\bar{Q}}$ is positive because the individual inventor receives the payment, but other inventors win the prize by rushing. In the latter case, $G_{Q\bar{Q}}$ is obviously zero. $G_{\bar{Q}Q}$ is the pay-off to a rushing inventor assuming other don't rush, the gain depends crucially on the anticipated number of uncommitted manufacturers, $(n-n^e)$. It is zero if all manufacturers are committed. $G_{\bar{Q}\bar{Q}}$ is the expected gain if all inventors rush, and from (2), it must equal zero. If $n^e < n$, and search cost is positive, both G_{QQ} and $G_{\bar{Q}Q}$ may be positive and no a priori prediction can be made about the dominant stretegy. However, inventors know the outcome of the manufacturer-manufacturer game. Thus, $n^e = n$.[14] This implies that $G_{QQ} = 0$ and $G_{\bar{Q}Q} < 0$ if search cost is zero; $G_{QQ} > 0$ and $G_{\bar{Q}Q} < 0$ if search cost is positive. In either case, quoting a lower price is a dominant strategy and P2 is a derived result.

(3) The inventor-manufacturer game.

The equilibrium in the above two games is determined through the solicitation of competitive bids among potential inventors. Negotiation between an inventor and a manufacturer, however, may take a different direction. A manufacturer may attempt to bargain the royalty downward by threatening to leave the industry. This bilateral bargaining possibility has received much attention in the literature on public goods. Much neglected, however, is the aspect of asymmetrical bargaining power in such a situation. The threat imposed by the manufacturer on the inventor is the latter's loss in revenue, $\pi_i q$. This is infinitesimal when compared to the cost of the innovation, C, if n is large. In fact, if search costs are zero, (4) implies that the threat will be zero. On the other hand, the loss in revenue to the manufacturer if the threat is unsuccessful is quite large relative to the sales of the manufacturer, i. e. $(\pi_o - \pi_t)/AC_o$ is large. Thus the threat imposed by an individual manufacturer will not be taken seriously and the inventor will not revise his quoted price unless he observes a lower bid from other inventors.[15]

A large number maintains stability in the above three games. A manufacturer would not bribe an inventor to rush because diseconomies of scale in production imply that the monopoly rent produced by himself alone in the product market is not likely to cover the cost of the innovation.[16] Similarly, an inventor would not bribe a manufacturer out of precommitments, because with large n, the bribing of one or two manufacturers would not affect the pay-offs G_{QQ} and

$G_{\bar{Q}Q}$ in the inventors' game. Both possibilities of bribing someone out of a prior contract involve large numbers that can be costly.

II.

The previous section determines only the competitive amount of payment to an innovation. We now analyse the method of payment that would serve as an inducement to the delivery of future development after the signing of prior contracts. Klein and Leffler (1980) considered numerous nongovernmental enforcement methods to reduce cheating and reneging of contracts. In the same spirit, this section argues that the structure of royalty rates, expressed per unit of output utilizing the innovation, can serve the same purpose.

The cost reduction given by an innovation depends on the amount of inventive resources that are put into it. Thus, we can write $AC_s(R)$. When manufacturers compare inventors, they look for the largest cost reduction with the least royalty rate. For analytical simplicity, I assume that the cost reduction mutually understood by the manufacturers and the inventor is one that maximizes the social value of the innovation net of cost.

$$\max_R \int_{AC_s(R)}^{AC_o} Q(p)dp - R$$

First order condition is

$$-Q \cdot \frac{\partial AC_s}{\partial R} = 1 \qquad (7)$$

MG in Figure 2 represents the left hand side of (7) and MC is 1. Their intersection gives the optimal R^*. The main problem is to choose a royalty structure in the prior contract so that the inventor has private incentive to actually deliver R^* after the contract is signed.

Stipulating payment conditional on R is an obvious choice, but R is difficult to measure and its value is difficult to estimate. In the analysis of Klein and Leffler, the quantity of a product is implicity assumed to be easily measurable, and a premium of price expressed per unit of product can serve as an honesty premium to its quality. Here, both problems (quantity and quality) exist, and payment of R has to be expressed in terms of a third dimension. output Q.

Consider the post-contract gain to an inventor if a royalty rate, π_t, per unit of output is stipulated. Depending on the product price, p_t, $Q(p_t)$ units of output will be produced in the product market. Thus the total private gain is $\pi_t \cdot Q(p_t)$.

$$p_t = \pi_t + AC_s(R) + \frac{s(t)}{q} \tag{8}$$

(8) differs from (5) in that the former's AC_s shifts down gradually as the inventor develops his idea (i. e., R increases), whereas the latter's AC_s is the anticipated level corresponding to the optimal R^*, i. e. AC_s in (5) = $AC_s(R^*)$ in (8).

To determine how much resources an inventor would actually put in <u>after</u> the prior contract is signed, the inventor

$$\max_R \ \pi_t \cdot Q(p_t) - R$$

The first order condition gives

$$\pi_t \, Q' \frac{\partial AC_s}{\partial R} = 1 \tag{9}$$

The left hand side gives the private marginal gain to the inventor of delivering the development. Its magnitude depends on the royalty charged, π_t, the slope of the demand curve, Q', and the innovation capability, $\frac{\partial AC_s}{\partial R}$. Although the functional forms of the latter two variables are exogenous, π_t is subject to choice in a prior contract. With a linear demand curve, raising π_t, would necessarily encourage post-contract development. In fact, combining (7) and (9) gives the <u>marginal</u> royalty rate, π_t^*, necessary to induce R^*.

$$\pi_t^* = \left|\frac{Q}{Q'}\right| \tag{10a}$$

or alternatively, $$\frac{\pi_t^*}{P_t} = \left|\frac{1}{\eta}\right| \text{ where } \eta \text{ is the elasticity of market demand} \tag{10b}$$

A uniform royalty rate per unit of output satisfying (10) undoubtedly gives the inventor a positive profit if inventive capability is subject to diminishing returns (see MG' in Figure 2, where the profit can be represented by efg). This does not give rise to any inconsistency with our analysis in the previous section, Anticipating the positive profit, competing inventors would offer rebates or some forms of "brand name capital investment" in the prior contracts (See Klein and Leffler). Thus, the net average royalty rate is still subject to the bidding tâtonnement in (3); and if search cost is zero, (4) still holds.

The most interesting interpretation of (10a) and (10b) is that the gross royalty rate can be smaller or larger than the product price depending upon the elasticity of market demand. In other words, it is possible that a patent license specifies a royalty rate of $1 per unit of output, but the output is selling at less than $1. The key to understanding this paradox again relies on the distinction between gross and net royalty rates discussed above. The manufacturer may be paying $1 royalty per unit of output, but receives a large enough subsidy in other dimensions that average total cost including the net royalty is less than $1.

A hypothetical example will illustrate this possibility. At the time when prior contracts are signed, the inventor puts up a collateral bond, and the interest from the bond is payable to the manufacturer depending upon the latter's production rate, e.g. the tie-in of "free" servicing of the machines. The inventor thus sees the gross royalty rate as the relevant marginal gain to recoup the interest loss on the bond, but the manufacturer sees the net royalty rate (gross rate minus free servicing) as the marginal cost.

Other more complicated structures of royalty rate can in principle serve the identical function as a uniform royalty rate with rebate. Consider a general form of royalty structure:[17]

$$\bar{\pi}_t = f(Q) \tag{11}$$

An example of (11) may be block rates, i. e. a uniform rate up to a certain output and other rates for higher outputs.

To induce development under competitive prior contracting, f(·) must satisfy the following three relationships jointly:

$$\frac{Q^*}{Q^{*\prime}} = f(Q^*) \tag{12}$$

$$Q^* \pi_t = \int_o^{Q^*} f(Q)QdQ = C \tag{13}$$

$$Q^* = Q(\pi_t + AC_s(R^*) + \frac{S(t)}{q}) \tag{14}$$

(12) assures optimal post-contract development, (13) assures zero profit for identical inventors, (14) assures perfect competition in the product market. To the extent that f(·) exists, it must take the form of MG'' in Figure 2. The shaded areas must be equalized. Empirical test of this proposition, however, may be difficult.

III.

Prior contracting requires manufacturers in an industry to identify potential inventors and evaluate their inventive abilities. The cost of acquiring such information largely determines the timing and the proportion of future development included in a patent license. This section provides several testable propositions in light of these constraints to illustrate how innovation related problems can be analysed by the alternative view in the paper.

<u>a. Implications regarding the inventive reward per machine utilizing the innovation.</u>

Consider two alternative models, A and B, in a production process of Q;

each reduces the average production cost of Q by a and b dollars respectively, $a > b$. With perfect competition in the output market, model A in the long run will receive (a-b) per unit of Q on each machine while B will receive nothing. However, if the relative superiority of the models cannot be ascertained at the introduction date, and both models have been improving over time at rates of g_a and g_b respectively, the long-run payment rate of A would approach the trend of $(a-b)e^{(g_a-g_b)t}$. Before the inferiority of B is known, let's say at time T, one expects to see certain price cutting, with the rate of A approaching this trend at T. The market shares of the two models similarly may fluctuate but they approach 1 and 0, respectively, at time T.

So far there are no distinctive implications generated by the alternative view. After time T, however, the traditional view implies the payment rate of A would increase at a faster rate, g_a, because improvements on B would be discontinued as its market share drops to zero. On the other hand, the alternative view argues that prior contracts would be made at time T, and for the licensees signed up at that date, the payment rate should continue at a rate as if B is still around, i. e. $g_a - g_b$.

The difference between the two views can be illustrated on Figure 3. The y intercept of line MNG, MO, denotes the payment rate if no improvement is made on either model, i. e. (a-b). The slope of line MN represents the rate of improvement and thus the rate of long-run competitive payment of the superior model A, i. e. $g_a - g_b$. If there were no prior contracting at T, the payment rate ought to follow QN after T, the slope of which equals g_a. If there were prior contracting, the payment rate would follow NG, the same rate as before time T.

Figure 3 is no doubt a drastic simplification of the real world which often has numerous models introduced initially. Such models may require different time lengths to be evaluated, and thus a different quitting time, T, for each model. The divergence of the payment trends in Figure 3 would then be a gradual process rather than a discrete departure as drawn. Intuitively, the closer the difference in the inventive potentials of two models is (i. e., the flatter the line MN is), the more difficult it would be to sort out the superior method, (i. e., the larger T would be). Similarly, the greater the inventive potential of a certain technology is (i. e., the steeper line NQ is), the greater would be the incentive to prior contract (i. e., the smaller T would be).

The simplest way to test these implications may be to run a regression with inventive reward per machine as the dependent variable, and time and the interaction of time and changes in market shares of the models as the independent variables. Prior contracting implies that the coefficient of the interaction term would be insignificant, whereas the traditional model implies the sign would be positive. Furthermore, for reasons just mentioned, one should examine the sensitivity of the regression results with respect to the length of time different models coexit in the market, the technological opportunity of the industry, and the variability in market shares of the dominant model. The econometric model suitable for testing these implications would probably involve a system of simultaneous equations, because price cutting among different models before time T would result in changes in the market shares as well.

b. Implications regarding the behaviors of licensees

The traditional monopoly model of patents views the manufacturers in an industry reacting passively to whatever licensing policy is imposed on them by the patent holder. The alternative model of prior contracting views the manufacturers actively searching and comparing inventive potentials of different research organizations. However, depending on the gain and cost conditions faced by the manufacturers, each may devote a different amount of resources to searching. Those who search more would sign up first and should receive advantages over late licensees who search less. This line of reasoning implies that the early licensees ought to have larger output and faster growth rate than the late licensees. A larger output means a higher incentive to search, because once a low-cost method with low royalty rate is found, it can be applied on a larger scale, thus increasing the gain per unit of search.[18] A faster growth rate signifies an alert manufacturer who can cope with changes in the industry, a la Stigler's survival principle.[19] A faster growth rate also follows from expansion of the earlier licensees who have an efficient model relative to the late licensees. In the limiting case, of course, late licensees could be driven out of business before they even have the chance to sign up.

The above discussions have important implications on the often discussed relationship between structure and performance in innovation activities. Related literature in the sixties mostly endorsed the Schumperterian view that concentration has a positive influence on R & D.[20] Recent writings have pointed out at least two major caveats to these studies. First, there is a distinction between concentration in the output market and concentration in the R & D market (Dasgupta and Stiglitz, 1980, a and b; Kitch 1978; Yu, 1981). The latter appears to be more appropriate if one adheres to the structure-performance paradigm. Second, concentration in the output market and R & D are simultaneously determined, (see Nelson and Winter, 1978; Futia, 1980; Dasgupta and Stiglitz, 1980 a and b). Specifically, it is believed that R & D increases output concentration, which in turn affects R & D. The result of R & D increasing concentration can be easily explained by the alternative view provided here. The larger manufacturers and those that have higher growth rates tend to be the earlier licensees. This in turn speeds up their growth rates making the industry more concentrated. In fact, the larger the R & D effort, ceterus paribus, the higher is the incentive for these licensees to prior contract and the more concentrated the output market should become. While this result is similar to the one suggested by Nelson and Winter, the reasoning is quite different. They assume all firms vertically intergrate their R & D effort, and the driving force behind the successes of firms is successful innovation. Here, specialization and division of labor between R & D and manufacturing is explicitly recognized, and the success of a manufacturer results from his efficency in forecasting what will sell in the future and in his searching behavior.

c. Implications regarding the pricing method in patent licenses.

It is difficult to categorize the great diversity of pricing methods found in patent licenses. But roughly speaking, one can think of two broad categories--a lump sum payment and a running royalty rate based on some measure of output. While the choice between these two payment methods often depends on the physical characteristics of the innovations, the heterogeneity of which perhaps precludes sweeping generalization, the explanation in section II suggests an enforcement role that a running royalty can play. Two implications directly follow from this notion: First, in situations of much postcontractual development, one should expect some form of running royalty, and the base on which the rate is calculated should be a margin on which the licensor can improve. An example concerns a glass feeding device in the 1920s.[21] In the manufacturing process of glass containers, molten glass must be fed through a feeder which consists of a reciprocating plunger and a shearing mechanism. The plunger and the shears coordinate in cycles in discharging "gobs" of molten glass into molds where containers will be made. Improvements on the feeder, both in terms of speed and quality, have been noted after the machine was first commercialized.[22] Accordingly, a running royalty rate based on gross of glasswares produced was observed in the patent licenses.[23] It would seem that the faster the licensor made the machine run, the more royalty he would receive per machine.

The second implication has to do with the method of price cutting in periods when the relative superiority of different models has not yet been sorted out (see implication (a) in this section). The traditional monopoly view cannot predict whether it is the lump sum or the running royalty rate that will be cut. Recognizing the enforcement function of a running royalty in prior contracts implies that this rate ought to be relatively rigid. If the commitment to future research remains the same during price cutting, only the lump sum component will be lowered, leaving the same "bonus" for inducement of future development. However, the actual testing of this implication may be largely handicapped by the empirical difficulty of categorizing lump sum vs. running royalty payments, the inclusion of costs of physical machinery which vary according to the supply conditions of the raw materials, changes in exogenous conditions that result in changes in commitment of future development, and other transaction cost considerations in licensing patents.

Conclusion and Remarks

This paper deals with situations where research organizations license patentable information to manufacturers. It is argued that competition in the inventive market as well as the production market would result in prior commitments by both the licensor and the licensees. The licensor commits himself to future development which the licensee also commits himself to accept. In so doing, the private return to a patentable innovation will fall from the demand price to a level equaling the cost (quality adjusted) of the next best research organization and the licensor-inventor would not rush to innovate. This resulting arrangement is called prior contracting.

The contractual commitment of future innovation is quite practical and happens frequently. Inventors are hired every day with some understanding of the expected value of their future research which is not yet observed and often is impossible to define. In the same manner, we ask: why can't manufacturers work out similar arrangements with research organizations? Prior contracting of an "unclearly specified" commodity can be enforceable if there is an incentive premium. This paper also argues that a running royalty rate in patent licenses can serve this purpose.

The observation which motivates this study could indeed be explained by a risk sharing hypothesis. While no attempt has been provided in this paper to differentiate empirically this hypothesis from the prior contracting view, we have examined several potentially testable propositions which may distinguish this view from the traditional monopoly view of patent. These implications (in section III) do not appear to follow directly from the risk sharing hypothesis.

Table I

Year	Motor Vehicle Factory Sales U. S. Plants (Passenger Cars Only)			4. Estimated royalty at 1 1/4% of listed Price	5. Actual royalty	6. Estimated % of cars escaping royalty
	1. Number	2. Value (000)	3. Average Price			
1903	11,235	$13,000	$1,157	$162,500	$153,784	5.36
1904	22,130	23,358	1,055	291,975	253,273	13.21
1905	24,250	38,670	1,594	483,375	413,958	14.33
1906	33,200	61,460	1,851	768,250	564,535	26.51
1907	43,000	91,620	2,130	1,145,250	508,058	55.62

Column 1 and 2 — Automobiles of America, Motor Vehicle Manufacturers Association of the United States, Inc. p. 283

Column 3 — Column 2 ÷ Column 1

Column 4 — Column 2 x 1 1/4%. The rate was specified in Selden's patent license. See the contract in R. C. Epstein's The Automobile Industry, the appendix

Column 5 — The Automobile, Vol. 18, No. 19 (May 7, 1908) p. 656. Taken from a footnote in John B. Rae, American Automobile Manufacturers: The First 40 years.

Column 6 — Assuming the percentage of licensed cars of the Selden patent was the same for high price cars as for low price cars, and assuming there was no cheating on the reported royalty of the licenses, the cars licensed can be found from solving the following equation

$$\frac{\text{actual royalty}}{\text{cars licensed x average price}} = 0.0125$$

$$\text{cars escaping royalty (column 6)} = 1 - \frac{\text{car licensed}}{\text{column 1}}$$

Table II

		Other Manufacturers	
		(E) Search and Commit	($\bar{E}$) Relax and Wait
Individual Manufacturer	(E) Search and Commit	$G_{EE} = (P_t - AC_s - \pi_t)q - S(t)$	$G_{E\bar{E}} = (P_o - AC_s - \pi_t)q - S(t)$
	($\bar{E}$) Relax and Wait	$G_{\bar{E}E} = (P_t - AC_o)q$	$G_{\bar{E}\bar{E}} = (P_o - AC_s - \pi_o)q$

Table III

		Other Inventors	
		(Q) Quote a lower price	($\bar{Q}$) Refuse to quote a price but rush instead
Individual Inventor	(Q) Quote a lower price	$G_{QQ} = \pi_t q\ n^e - C$	$G_{Q\bar{Q}} = \begin{cases} \pi_t q \cdot n^e \\ 0 \end{cases}$
	($\bar{Q}$) Refuse to quote a price but rush instead	$G_{\bar{Q}Q} = \pi_o q\ (n - n^e) - C$	$G_{\bar{Q}\bar{Q}} = \pi_o qn - C - \Delta c$

Figure 1

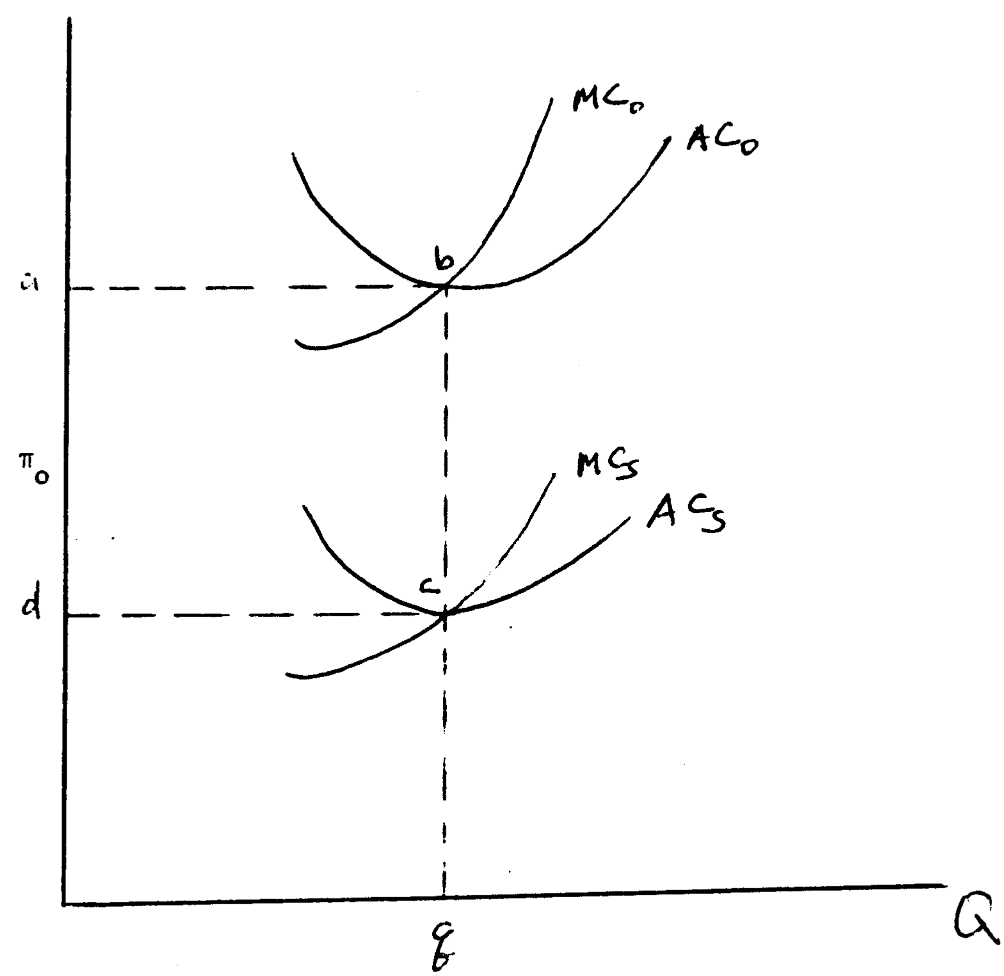


Figure 2

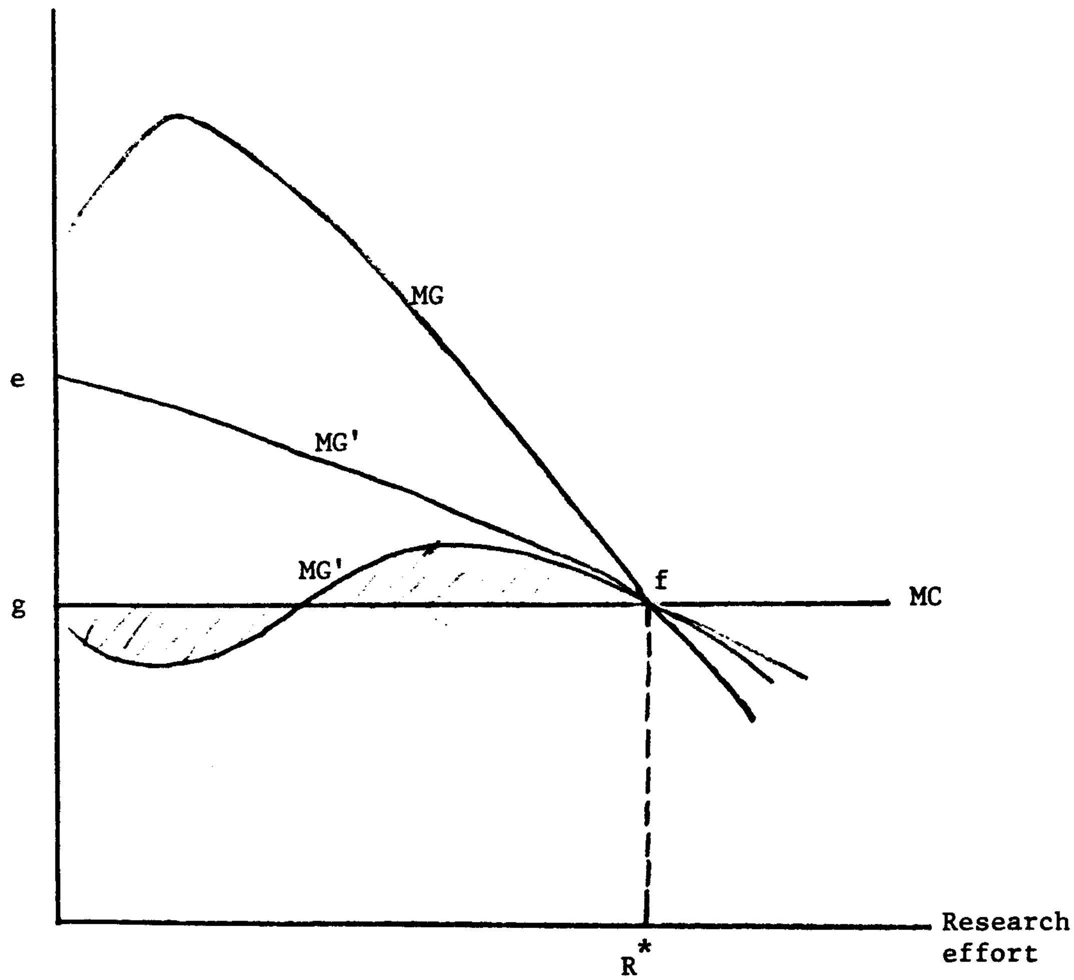
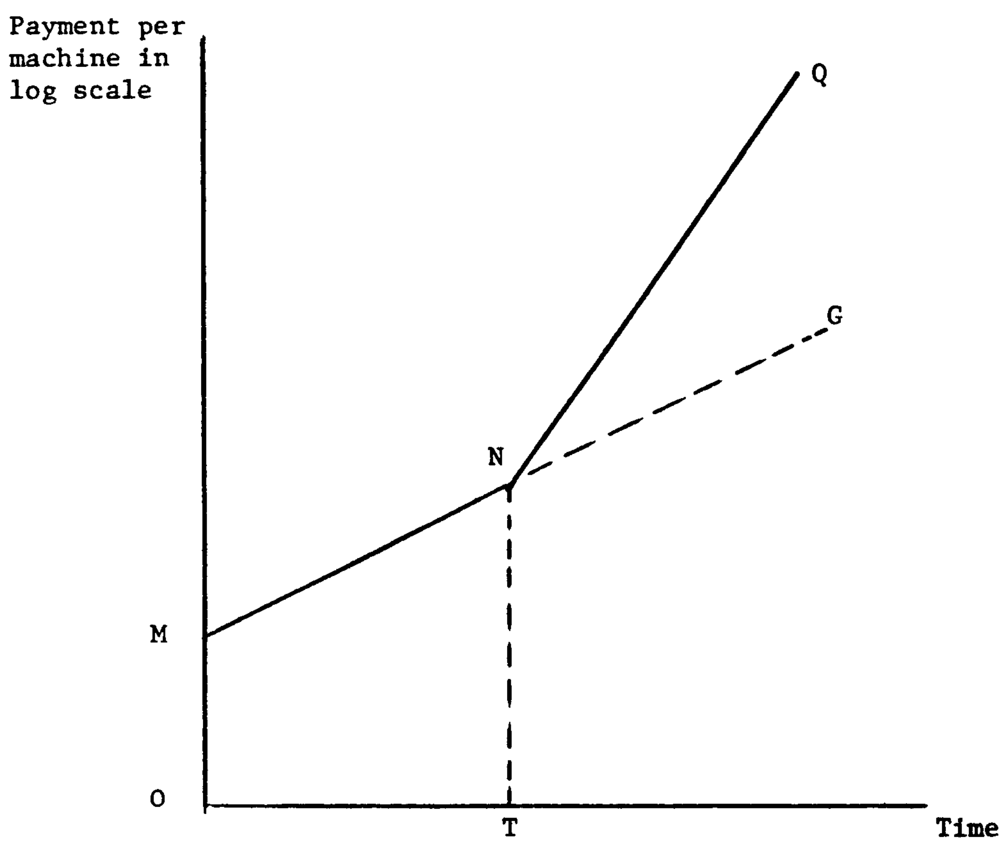


Figure 3



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Footnotes

1. See McGee (1966), Bowman (1973), and Priest (1978).

2. See a general description of patent licenses in an NSF report by Cheung and others, (1976).

3. U. S. Congress, House, Committee on Patents, Pooling of Patents, (1936).

4. License between Electrical Research Products, Inc., and Hal Roach Studios, May 18, 1928, Pooling of Patents, pp. 1410 to 1420.

5. No future patents were included in the licenses of this dominant patent. The license can be found in R. C. Epstein's, The Automobile Industry (1928), the appendix.

6. The same proposition was casually suggested in Carl Kaysen's detail case study of U. S. v. United Shoe Machinery Corporation in 1956, pp. 190-91. The logic and the implications of the proposition, however, have not been examined.

7. The common observation that a research organization requires its employed inventors to grant exclusive rights or assignments to the company is a contractual behavior that must be explained rather than asserted. There is no reason why the inventor's contract cannot be nonexclusive. In fact, many patent licenses between research organizations (i. e. representative of inventors) and manufacturers are nonexclusive.

8. The race to invent has recieved much attention since Barzel made the proposition in 1968. Cheung (1976) suggested that inventors would not rush if one inventor is known to be faster and more able than others. In such situation where inventors have different cost of inventing, he argued, the equilibrium royalty rate would cover only the cost of the second lowest cost inventor. However, he did not examine situations where inventors have identical cost.

9. Inventor's misuse of such a commitment by nondelivery will not happen if there are repetitive purchases and/or an appropriate method of payment is used. This will be the subject matter of section II.

10. This formulation is mainly for expositional purposes. Without price discrimination, the profit maximizing royalty will be less than π_o if the market demand for output prior to innovation is elastic. Market output will be larger, thus allowing a larger number of manufacturers. Futhermore, a welfare triangle in the product market is also unavoidable. The first complication can be handled by redefining π_o, and noting that the number of manufacturers, n, is large, thus the effect due to entry on this number is small. The second complication has bearing only on the structural form of the patent license. It will not affect the gist of the argument in the text.

11. Implicit in this search process is the assumption that the cost and the comparative advantages of different inventors cannot be known with perfect certainty and thus the search performs a useful social function. Furthermore, a perfectly consistent model might have to assume that the search cost of the manufacturers cannot be known with certainty. For related theoretical issues, see Butter (1977), Wilde (1977), and MacMinn (1980).

12. Economists have considered two classes of search behaviors, the non-sequential search, Stigler (1961), and the sequential search, McCall (1970).

13. The specification of the marginal gain function depends on the type of search adopted; see Stigler, McCall, ibid.

14. The possibility of new manufacturers entering the product market appears to be a red herring. A potential entrant would like to get ahead of existing manufacturers and he would be a player in the manufacturer-manufacturer game to begin with. As a practical matter, commitment of potential entrants may be difficult. But given positive marketing cost of new firms, it is also unlikely that an inventor would attempt to seek control of the whole industry by relying on these new firms.

15. Professor Earl Thompson has suggested to me an alternative way of looking at the problem. Because the gain to winning a bargaining game is higher to an inventor than to an individual manufacturer, an inventor would commit more resources to making a rigid price commitment than an individual manufacturer would. Thus, the inventor is likely to win the bargaining game.

16. A finite social value of an innovation and an infinite number of manufacturer together imply an infinitesimally small firm size. To have monopoly rent by a single firm greater than the cost of innovation it would require a very flat marginal cost of production. See Thompson's discussion paper.

17. Note that we cannot express π_t as a function of R because it is precisely the difficulty in measuring R that requires alternative contract specifications.

18. The same principle has been applied on investment in human capital. Those who work more hours have a higher incentive to acquire education. See Barzel and Yu.

19. Stigler (1958)

20. See the review article by Kamien and Schwartz (1975); a notable exception can be found in Arrow (1962)

21. See United States vs. Hartford-Empire Co., 323 U. S. 386 (1945).

22. See Testimonies of A. Hunter and K. Peiler in the court transcript, pp. 9512-9712 and pp. 7739-8705.

23. The transcript has copies of 319 contracts. Those written between Hartford-Empire and the glass manufacturers all have a standard royalty schedule.