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## Conference Paper

# Licensing with Free Entry

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# Licensing with Free Entry\*

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## Abstract

The literature on the licensing of an innovation has mainly focused on some specific contract types. We show within the framework of a fairly general model that removing these contractual limitations will lead to extreme market outcomes. Specifically, we find that when the patentee can employ observable contracts that can condition on market entry, it can achieve the monopoly outcome. Furthermore, when the patentee can only use unconditional quantity forcing contracts, it captures the entire market, albeit not at monopoly price, via a single licensee. Our results point out to the significance, and perhaps the particularity, of observable, non-renegotiable contracts.

**Keywords:** Patent licensing, free entry, quantity competition.

**JEL Classification:** D45, K11, L11, L13, L21, L41.

# Introduction

We re-examine the question of licensing a cost reducing technology in a Cournot oligopoly. In this paper, we extend the existing literature that addresses this question by relaxing the contractual assumptions and by endogenizing the number firms in the market. Most of the theoretical models in the licensing literature are based on the framework established by Kamien and Tauman (1986) and Katz and Shapiro (1986). An innovator has acquired a patent for a technology that lowers costs. In a multi-stage licensing game, contracts are offered or auctioned by the innovator, firms buy licenses or bid for them. Observing the resulting market structure as well as the final licensing contracts, licensees and non-licensees compete.

The strategy followed in this literature, which we briefly review below, has been to first fix a contractual form for the licenses, and then derive the equilibrium contracts and corresponding magnitudes of interest. The analysis is then repeated with an alternative contractual form and the findings are compared. Various contractual forms have been analyzed, starting with pure fixed-fee and per-unit fee contracts. More recently, revenue sharing and tariffs with multiple components, e.g. two-part tariffs, have been put in focus.

A typical result in this literature is that the innovator cannot extract the full surplus of its innovation. This is basically due to the inefficiency of the contractual forms employed. It has been pointed out by Sen (2002), Erutku and Richelle (2006) and Erutku and Richelle (2007) that with more general contracts the innovator can achieve the monopoly outcome. The revenue from the license in that case might even exceed the social surplus generated by it. These papers, following the extant literature, assume that there is a finite set of possible competitors in the industry. The optimal licensing scheme to monopolize the market has the property that the innovator has a licensing contract with *every* potential competitor in the market. In the case of an inside innovator, as in Sen (2002), the licensing contract only tells the licensee to stay inactive, while the innovator produces the monopoly quantity. In general, these papers as well as Sen and Tauman (2007), who look at optimal auctions using fixed-fee and royalty payments, suggest that to extract the full surplus from the licensees requires licensing the technology to (nearly) all potential competitors in the market. According to this literature, a single or no license (in case of an inside innovator) is only optimal in case of a drastic innovation. In the language of Arrow (1962) a firm that uses a drastic innovation is sufficiently efficient that it can produce the monopoly quantity associated with its costs without having to fear competition.

Apart from a few papers in the literature, the commitment power that observable contracts provides is not acknowledged. In our model we explicitly make use of this

property. Observable contracts which bind the contracting parties to actions in every contingency have the power to implement their most preferred outcome. By committing to actions that would harm rivals in any other outcome, it is not difficult to induce this result. Seen from this perspective the contractual forms that are often used in the literature, apart from a handful of papers, are overly simplistic.

In this paper, we first formalize these ideas and show that a patentee who can employ contracts conditional on the number of active firms in the market can easily achieve the monopoly profits associated with the new technology by signing a *single* contract.

Contrary to the previous literature we also assume that there is an infinite number of potential competitors. Still, the number of competitors in the market will always be finite as potential competitors face positive “entry” costs for being active in the market. However, in such an environment, the number of active firms in the market will be endogenous in the contracts offered. This feature of our model contrasts with the existing literature which often assumes that the number of active firms in the market is fixed, as those firms who do not receive a license continue producing with the existing technology. Although with contracts conditional on the number of active firms the patentee can achieve the monopoly profits regardless of the level of fixed entry costs,<sup>1</sup> this no longer is the case when contracts are restricted to be conditional upon the output of a licensee.

Next, we show that contracts that can only specify payments conditional on the quantity and revenue of the licensee can still implement the most preferred outcome to the patentee. The argument is that revenue and quantity based incentives allow the patentee to implement reactions of the licensee that are aggressive to entry while producing the monopoly quantity on the equilibrium path when no entry takes place. In this setting, we show that the patentee will only sign a *single* contract. In equilibrium all production takes place using the more efficient new technology and this output is produced by the single licensee.

Finally, we explore the case where the contracts are still observable but they can depend only on the output of the licensee. We show that the patentee will always use the licensing contracts to deter entry by all non-licensees, but the monopoly profit is in general not attainable. The patentee will either use a single or two contracts. If the licensee uses a single contract this contract is equivalent to quantity forcing, giving the licensee the incentive to produce the deterrence quantity in any case. In particular, with

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<sup>1</sup>A contract which specifies an output that drives the market price below the marginal cost of existing technology in case of entry would induce non-licensees to remain inactive. This argument implicitly assumes that even when fixed entry costs are zero, firms need to decide whether to be active or not and this decision is irreversible.

a single license, it not possible to deter entry and make the licensee produce a lower quantity than the deterrence quantity on the equilibrium path. In contrast with two licensees this is possible, however at additional fixed costs. The patentee will thus trade off the additional profit due to the higher market profits with the additional fixed costs of the second licensee. In equilibrium all production takes place using the more efficient new technology. All other potential firms in the market remain inactive. Despite the fact that the licensee is effectively rendered a monopolist, with a single licensee it is necessary to commit to a very high level of output in order to deter entry/induce exit. Thus, overall welfare need not decline.

Regardless of whether contracts can be conditioned on the number of active firms or not, we show that often only a single contract will be issued. This finding is in sharp contrast with findings of Sen and Tauman (2007) who show that in their setting with (no fixed costs and at best two part tariff contracts) almost all existing firms would receive a license. Although the single license creates a very concentrated industry, the resulting outcome may have desirable properties, especially in the case that firms only use quantity based contracts. In that case, interestingly, the market outcome when the patentee uses two licensees is strictly worse than the outcome with one licensee from the point of view of (static) efficiency.

Our results highlight the importance of the commitment power provided by observable contracts. In fact, we show that observable contracts that can be conditioned on the number of active firms can allow the innovator to earn full monopoly profits associated with the innovation. However, in case of entry, whether the contracting parties would follow through with the threats the contract contains is not clear. Absent contractual commitment there seems to be no reason to do so. Moreover, given a possibility to renegotiate, they certainly would revise their actions as a response to entry. Thus, a potential competitor might not take the commitments provided in the contract on their face value. Thus, a future direction to explore should definitely involve unobservable licensing contracts or renegotiation proof observable contracts at the very least.

The paper is organized as follows. In Section 1, we outline our model. Section 2 presents our main results for different complexity of contracts. Following our results on market outcomes, in Section 4 we provide some welfare results. Section 5 concludes.

## 1 Model

Consider a homogenous product market with infinitely many identical firms that have access to the same production technology which allows them to produce at marginal

cost  $c$ . In order to operate in the market, a firm has to incur a fixed cost  $F > 0$ . All active firms compete in quantities, where  $q_i$  denotes the output choice of firm  $i$ . The industry inverse demand is given by  $P(Q)$ , where  $Q$  is the total output supplied and  $P'(Q) < 0, P''(Q) \leq 0$ . An innovator firm,  $I$ , acquires a patent for a new production technology that lowers the marginal cost of production to  $c - \delta$ , where  $c > \delta \geq 0$ , while leaving the fixed cost unchanged. The innovator can license the technology to a number of other firms.<sup>2</sup> In order to exclude the uninteresting case of a natural monopoly, or a blocked entry outcome, we are going to assume that fixed costs are sufficiently low such that when the innovator itself produces the monopoly output, there will be entry into the market.

The timing of the game is as follows:

- *Stage 1:* The innovator signs observable and not renegotiable licensing contracts with  $L$  firms.
- *Stage 2:* Having observed the licensing contracts, the non-licensee firms make their entry decisions. All firms, including the licensees, that enter the market incur the entry cost  $F$ .
- *Stage 3:* All active firms observe the number of active firms and then compete by choosing their quantities simultaneously.

## 1.1 Contractual Forms

It is clear that what  $I$  and its licensees can achieve in terms profits depends heavily on the set of contracts that are available to them. We start by allowing the contractual parties to add any relevant variable or conditional clause into their contracts, as long as these are verifiable and observable by the contractual parties at the beginning of the third stage quantity competition. So initially we assume that contracts are “complete”, or that they can specify a different action – and a corresponding payment from the licensee to the innovator, for any contingency that can arise. We will then restrict the available set of contracts to those that do not condition the actions of the licensees on the contingencies.

The determination of the contracts can take place through many different mechanisms. The common assumption in the literature is that the patent holder makes take-it-or-leave-it offers to the licensees. In this case, the patent holder must take the outside option of the licensee into account and provide it with at least as much profit as it would earn by

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<sup>2</sup>It is relatively simple to show that all of our results apply to the case where the innovator can choose to produce the good itself, but that this never arises in equilibrium.

rejecting the contract. Since there is an infinite number of potential downstream firms and because of the fixed entry costs only a finite number of them will be active in equilibrium, rejecting the contract offer results in an expected payoff of zero. We therefore set the outside option of a licensee to zero.<sup>3</sup>

## 2 Licensing contracts

### 2.1 Optimal contracts

In this section we derive the outcome of optimal licensing contracts. We provide an example for a simple optimal contract that specifies payments for each licensee depending on the quantity the licensee sells and conditional on the number of non-licensees in the market. This contract is sufficiently "complete" in the sense that it achieves the same maximal profit as a contract that can condition payments on all contingencies. Formally, we look at contracts that specify payments  $t(X)$ , where  $X$  is a vector of contingencies. Initially, we allow all  $X$  to contain all relevant contingencies, while later, we step by step restrict contingencies by, for example, allowing only to condition on the own output of the licensees.

With sufficiently complete contracts, the maximal industry profit is the natural upper bound for the profit the innovator can obtain from his license. Let us first characterize the industry profit maximizing outcome and then define contracts that yield maximal industry profits to the innovator.

Industry profits depend on the set of active firms, which have to pay  $F$ , and a quantity choice for each active firm. The set of active firms consists of two subsets, firms with the new production technology and firms with the old production technology. Clearly, industry profits are maximized if total industry output is produced with the best available technology. Hence, defining  $N$  as the number of active firms with the new technology, maximal industry profits are defined by

$$\max_{N, \{q_i\}_{i=1}^N} \sum_{i=1}^N \pi(q_i, \left( \sum_{i=1}^N q_i \right)),$$

where  $\pi = (P(\left( \sum_{i=1}^N q_i \right)) - (c - \delta))q_i - F$ . Note that productive efficiency requires that only one firm is active because of  $F > 0$ . Hence, industry profits are maximized if only

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<sup>3</sup>Note that this conjecture simplifies the formulation substantially but is not critical for any of the following results.



one firm is active  $N = 1$ . To maximize profits this firm then has to produce the monopoly quantity associated with the new marginal costs  $c - \delta$ ,  $q^m \equiv \arg \max_q \pi(q)$ .

In fact an optimal contract will achieve the same outcome.

**Proposition 1** *An optimal contract gives the innovator monopoly profits; only one firm, with the new production technology, is active. In particular, the innovator is able to extract monopoly profits with a single licensing contract that has payments conditional on entry of non-licensees and the output of the licensee.*

**Proof.** To show that the innovator can achieve monopoly profits consider a single (exclusive) take it or leave it licensing contract. This contract specifies that the licensee produces the monopoly quantity  $q^m$  if no other firm entered the market in stage 2. Clearly this can be achieved by making it very costly to produce any other quantity conditional on no entry. However, if a non-licensee entered the market the contract tells the licensee to produce a sufficiently large quantity  $q^d$ , such that entry would not have been profitable for any non-licensee in the first place. Again, this can be achieved by making other quantity choices prohibitively costly. This contract clearly deters entry by non-licensees. Hence, on the equilibrium path, the licensee faces no competition and, as specified, chooses  $q^m$ . The innovator can extract the whole monopoly profit of the licensee, as the outside option of the licensee is zero. ■

The result seems surprising, especially since it holds for the case that there is no cost advantage of the new technology,  $\delta = 0$ . In the case of no cost advantage the market is monopolized purely through the the vertical contract. The power of the optimal contracts lies, firstly, in the commitment power they hold. Secondly, by conditioning payment on contingencies, the contract allows to commit to off-equilibrium quantity choices without having to choose suboptimal actions on the equilibrium path.

## 2.2 Contracts with revenue and quantity dependent payment

We have seen that with observable contracts that are conditional on entry the innovator can monopolize the market and extract all rents. Such a contract credibly commits the licensee to be aggressive if entry occurs, however, on the equilibrium path the monopoly quantity is produced. For various reason, it is often implausible that a licensing contract can condition directly on the number of non-licensees in the market, as entry is not easily verifiable and such contracts might be forbidden by the antitrust authorities. In this section we show that it is possible to achieve the optimal outcome with contracts that are only conditional on the quantity and revenue of the licensee. The reason is that by

conditioning payments on revenue the contract indirectly conditions on market price which in turn is affected by entry. Conditioning payments on revenue is thus a good substitute for conditioning on the number of non-licensees in the market. Formally, the contract specifies payments from each licensee to the patentee  $t(R_i, q_i)$ , where  $R_i \equiv p(q_i + Q_{-i})q_i$  is the revenue of the licensee. Without further restrictions on the set of contracts, we can establish the following.

**Proposition 2** *The innovator can strongly implement the monopoly outcome with a single licensing contract with payments that are only conditional on quantity and revenue of the licensee.*

**Proof.** As a first step, note that a contract that has payments  $t(R_i, q_i)$  is equivalent to a contract that has payments  $\tau(q_i, Q_{-i})$ . To see that, note that  $R_i(q_i, Q_{-i})$  is strictly monotone in  $Q_{-i}$  as  $p(q_i, Q_{-i})$  is strictly decreasing in  $Q_{-i}$ . Thus  $R_i$  is a unique function of  $Q_{-i}$  for any given  $q_i$ . Hence, by additionally conditioning payments on revenue the innovator can condition the payments indirectly on the aggregate quantity of non-licensees.

Suppose the innovator wants the licensee to pick the monopoly quantity if no other firm entered, but to choose a larger deterrence quantity if there is entry. If this can be incentivized, there will be no entry on the equilibrium path of the game. Define  $q^d$  as a quantity that is sufficient to deter any entry but such that the reaction of a non-licensee to  $q^d$  if it entered nevertheless is a strictly positive quantity  $Q_{-i} > 0$ . Such a  $q^d$  always exists as there are positive fixed costs of entry. The monopoly quantity is called  $q^m$ . The incentive problem for strong ( $>$ ) implementation is the following, first for the choice of  $q^m$  on the equilibrium path, when there is no non-licensee ( $Q_{-i} = 0$ ):

$$\pi(q^m, 0) - \tau(q^m, 0) > \pi(q^d, 0) - \tau(q^d, 0), \quad (1)$$

and secondly for the choice of  $q^d$

$$\pi(q^d, Q_{-i}) - \tau(q^d, Q_{-i}) > \pi(q^m, Q_{-i}) - \tau(q^m, Q_{-i}). \quad (2)$$

From inspecting (1) and (2) it is clear that both incentive constraints can be satisfied independently from each other by conditioning the payment on  $Q_{-i}$ . Each individual incentive constraint can easily be satisfied by choosing sufficiently large transfers  $\tau(q^d, 0)$  and  $\tau(q^m, Q_{-i})$ . Note that it is sufficient to take only the incentives for  $q^m$  and  $q^d$  into account, as it is trivially possible to make all other quantity choices not attractive by specifying large payments otherwise. The participation of the licensee is ensured by choosing  $\tau(q^m, 0) = \pi(q^m, 0)$ , recalling that the outside option to the license has a value of zero. ■

This result reveals that contracts which can condition on the quantity choice of the licensee and indirectly condition on market entry independently from each other are sufficient to achieve the monopoly outcome. While this result relies on revenue-based payments, in general it is only necessary that the contract has sufficient instruments to condition on own quantity and the aggregate quantity of others. By the same argument, thus, contracts that can more directly condition on the market price or (aggregate) quantity of non-licensees are outcome equivalent. In the next step, we restrict the contracts further, such that they cannot be directly conditional on market price, revenue or quantity of the non-licensees.

### 2.3 Contracts conditional on own quantity

In this section we restrict contracts such that they can only base payments for a license on the quantity choice of the licensee. Examples for such contracts are two-part tariffs, three-part tariffs, or quantity forcing agreements. Initially, we do not restrict the functional form of the payments but instead allow for non-linear and non-continuous payments in the quantity of the licensee. We will show that given the limited set of contracts the innovator can still foreclose the market. Unlike in the case with entry-dependent contracts however, the monopoly profit is, in general, not attainable.

Any contract offered by the patentee will lead to a set of quantities chosen by its licensees that depend on whether, and to what extent, entry has occurred, although the contract does not explicitly condition on entry. Consider first the implementation of an entry deterrence outcome by the patentee. Since the best response of an entrant depends on the total quantity of the licensees and not on their individual quantities, the optimal number of licensees can be regarded as being one. Let us take this as given for the time being. The contract should specify a payment function that leads to the satisfaction of two incentive constraints: first, it should make the licensee choose the entry deterring quantity when entry were to take place, and second, the patentee should choose a – possibly different – profit maximizing quantity when entry does not take place. Formally, let  $q^d$  again be the quantity such that when entry occurs the entrant makes a non-positive profit. Furthermore, let  $\hat{q} < q^d$  be the quantity that the patentee tries to implement via the contract when entry does not take place. The two incentive compatibility constraints are

$$\begin{aligned} \pi_i(\hat{q}, 0) - t(\hat{q}) &\geq \pi_i(q^d, 0) - t(q^d) \\ \pi_i(q^d, Q_{-i}(q^d)) - t(q^d) &\geq \pi_i(\hat{q}, Q_{-i}(q^d)) - t(\hat{q}) \end{aligned}$$

where  $Q_{-i}(q^d)$  is the total best response output of the entrants when they expect the deterrence quantity to be produced.

Adding the two inequalities side-by-side and rearranging terms gives

$$\pi_i(\hat{q}, 0) - \pi_i(q^d, 0) \geq \pi(\hat{q}, Q_{-i}(q^d)) - \pi_i(q^d, Q_{-i}(q^d)) \quad (3)$$

which, given the assumption on market demand (strategic substitutability of quantities), is clearly unsatisfied for any  $Q_{-i}(q^d) > 0$  and satisfied with strict equality for  $Q_{-i}(q^d) = 0$ . Thus, unless the deterrence quantity  $q^d$  is sufficiently large enough such that in the case of entry the entrants' best response is to produce a quantity of zero, the patentee cannot implement an equilibrium outcome which yields profits higher than that of simple entry deterrence.

Let us first tackle the case where  $Q_{-i}(q^d) = 0$ . The implication is that the licensee finds itself in a position where, for the purposes of optimal choice of its quantity, the situation with entry is indistinguishable from that with no entry. This makes the licensee obviously indifferent between choosing  $q^d$  and the – from the patentee's perspective – more profitable  $\hat{q}$ . In other words, both of the licensee's incentive compatibility constraints are strictly binding. As a result there are two Nash equilibria of the Stage 3 subgame. Since the incentive compatibility constraints have to be binding, there is no contractual modification that the patentee can implement to make its licensee favour  $\hat{q}$  over  $q^d$ . Even though theoretically one can say that the monopoly outcome can be implemented by choosing  $\hat{q} = q^m$ , from the patentee's point of view there is no guarantee that the licensee will choose the monopoly quantity over the deterrence quantity. We therefore disregard this weakly implementable contractual outcome.

The above discussion shows that the patentee cannot (strongly) implement the vertically integrated monopoly outcome when the contractual space is limited. Furthermore, the patentee cannot implement any output below  $q^d$  while deterring entry via an off-equilibrium threat. Also note that allowing the entry of independent firms can never be part of an equilibrium, as the patentee can always capture their profit by licensing to one additional firm with a contract that lets the licensee mimic the behavior of the entrant. Having ruled accommodation of entry out, we now focus on the issue of multiple licenses. As shown earlier, the satisfaction of the incentive compatibility constraints of the licensees hinges on the inequality in (3). As it turns out, with at least two licenses the patentee can implement the production of the monopoly quantity while deterring entry. The next lemma states this result.

**Lemma 1** *The patentee can strongly implement the production of the monopoly quantity*

in equilibrium and deter the entry of all other firms by licensing to at least two firms. The profit of the patentee is then  $\pi^m - F$ .

**Proof.** We will prove this result for the case of  $L = 2$  as it is obviously more costly (in terms of the incurred fixed costs) and not optimal to implement the same outcome with more licenses. The offered contracts should induce each licensee  $i$  to choose a quantity  $q_i^E$  when entry takes place, and a different quantity  $\hat{q}_i$  when it doesn't. Given the quantity choices of the licensees, the independent firms should find it unprofitable to enter the market. At the same time, the incentive compatibility constraints of the licensees should be satisfied. This is the case when  $\hat{q}_i > q_i^E$  or when  $\hat{q}_i < q_i^E$  and  $Q_{-i}(\hat{q}_i) > Q_{-i}(q_i^E)$ . Note that due to the constant returns to scale nature of production technology and the fact that the patentee leaves zero surplus to its licensees in equilibrium, the quantities produced by the licensees in each subgame do not have to be equal. Then there is a simple set of quantities  $\{(q_1^E = 0, q_2^E = P^{-1}(c - \delta)), (\hat{q}_1 = q^m, \hat{q}_2 = 0)\}$ , such that the total output when entry does not take place equals the monopoly quantity, and when entry does take place total licensee output equals the deterrence quantity that sets the entrants' best response equal to zero. This set of quantities can theoretically be implemented by various (non-linear) contracts. For instance a pair of quantity forcing contracts that specify payments of  $(\pi^m, -F)$  from licensees 1 and 2 respectively at the equilibrium (no entry) path, and  $(-F, -F - \epsilon)$  at the off-equilibrium (entry) path will implement these quantities. ■

When it distributes two licenses, the patentee earns a profit of  $\pi^m - F$ . Whether this profit is higher than the deterrence profit that can be achieved by licensing to a single firm depends on the magnitude of the fixed entry costs  $F$ . The next proposition sums up all the findings of this section.

**Proposition 3** *When contractual clauses can only be conditioned on own licensee quantities,*

- i. the optimal licensing contract induces a single licensee to produce the deterrence quantity  $q^d$  if  $\pi(q^d) > \pi^m - F$ ,*
- ii. the optimal licensing contracts induce two licensees to produce  $(\hat{q}_1 = q^m, \hat{q}_2 = 0)$ , and  $(q_1^E = 0, q_2^E = P^{-1}(c - \delta))$  without and with entry respectively, if  $\pi(q^d) < \pi^m - F$ .*

What Proposition 3 says is that for sufficiently high fixed entry costs the best the patentee can achieve is to 'flood' the market by making a single licensee produce a high enough quantity. For lower values of the entry cost the patentee can implement the monopoly outcome, albeit at the cost of paying the fixed entry costs of two firms.

### 3 Specific Contractual Forms

In this section we look at a few specific cases where the available licensing contracts are limited to a few well known forms. One obvious conjecture is that the patentee will not be able to achieve the extreme profits resulting from more sophisticated contracts.

#### 3.1 Quantity Forcing Contracts

In this section we derive the market equilibrium when the patent holder and its licensees can jointly commit to their downstream quantities, but not to reaction functions that are dependent on observable market variables, via contracts. In other words, we now restrict the contracts to specify a single quantity-payment pair for each licensee<sup>4</sup>. Essentially, we are limiting the set of contracts to quantity forcing agreements.

We formulate the problem faced by the innovator when it can choose and sign contracts with a subset of potential firms as its licensees. Given that we only have one principal, the patent holder, the contracting problem is relatively easy:

$$\max_{L, \{q_i, t_i\}_{i=1}^L} \sum_{i=1}^L t_i(q_i)$$

subject to the set of participation constraints

$$\pi(q_i, Q_{-i}, Q_{-L} \left( \sum_i q_i \right)) - t_i(q_i) \geq 0, \forall i$$

where  $Q_{-i}$  is the total output produced by all licensees except  $i$  and  $Q_{-L}$  is the total output produced by all outsider firms. Clearly the participation constraint has to be binding as otherwise  $t_i$  can be increased to increase profits. The new problem is thus:

$$\max_{L, \{q_i\}_{i=1}^L} \sum_{i=1}^L \pi(q_i, Q_{-i}, Q_{-L} \left( \sum_i q_i \right)) \quad (4)$$

The contract leaves a profit to each licensee just enough to induce acceptance, that is, it leaves a payoff just equal to the profits the licensee would obtain in case it rejected the contract offer. With this insight at hand, it is straightforward to see that we need not rely on take-it-or-leave-it offers. The contracting firms could negotiate or cooperatively settle on a contract that maximizes their joint profit  $\pi(q_i, Q_{-i}, Q_{-L})$ , which would result in the

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<sup>4</sup>This restriction clearly goes beyond making the contracts unconditional upon the entry of outsider firms. It also does not allow the licensees to react differently to different market structures, e.g. to the number of entrants.

choice of  $q_i$ . Given the contracts, they can then share the resulting profits by means of fixed transfers.

**Lemma 2** *The optimal number of licenses with unconditional quantity forcing contracts is one.*

The outside firms only react to the total quantity produced by the licensees. Hence, having control over more than one licensee does not alter the commitment power, while having a smaller number of licensees saves on fixed production costs. With the optimal number of licenses at  $L = 1$ , it is clear that the problem faced by the patentee given in (4) is equivalent to that of a Stackelberg leader that chooses and commits to its output before other firms can react.

Given that the optimal contract between the innovator and its licensee enables them to commit to a single quantity, we are going to make use of the available results regarding a Stackelberg leader.<sup>5</sup> The main result is that the innovator chooses its contract to completely exclude non-licensee firms out of the market.

**Lemma 3** *In a Stackelberg quantity competition game with constant marginal costs and free entry, the Stackelberg leader deters the entry of all other firms by choosing a high enough quantity.*

**Proof.** See Appendix. ■

The above result is surprisingly strong given that it holds for a fairly general market demand. Given the equivalence of the problems faced by the Stackelberg leader and the patentee who can offer unconditional quantity forcing contracts, we have the following result.

**Proposition 4** *When the patentee can only offer non-conditional quantity forcing contracts, it chooses a single licensee to produce the entry deterrence quantity  $q^d$ .*

Proposition 4 implies that even with simple quantity forcing contracts the innovator does completely shut the market to other firms by committing to a large enough quantity of output via a single licensee. Although the monopoly profit cannot be achieved, for large enough values of the fixed entry cost simple quantity forcing contracts do as well as general contracts that condition on own quantities.

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<sup>5</sup>This analysis benefited from the analysis on Stackelberg competition with integer constraints in Etro (2007).

### 3.2 Two-part Tariff Contracts

In this section we will argue that two-part tariffs cannot achieve the same outcome as general own quantity based contracts, but in fact perform strictly worse than even quantity forcing. The reason is that a two-part tariff contract that is designed to implement full deterrence has the feature that the licensee will produce strictly more than the minimal deterrence quantity on the equilibrium path when no non-licensee enters.

Suppose initially that the patentee signs a contract with a single licensee. The contract specifies a two-part payment that includes a per-unit fee  $w$  and a fixed fee  $R$ . Once again accommodation is always dominated by signing multiple contracts. Hence, as with other types of contracts, the two-part tariff contract should implement a deterrence quantity  $q^d$  in the case when entry occurs and a different quantity  $\tilde{q}$  when there is no entry. These two quantities should satisfy the first-order conditions of profit maximization off (entry) and on (no entry) the equilibrium path:

$$\begin{aligned} p'(q^d + Q_{-i})q^d + p(q^d + Q_{-i}) &= c - \delta + w \\ p'(\tilde{q})\tilde{q} + p(\tilde{q}) &= c - \delta + w \end{aligned}$$

Adding the two equations side-by-side and rearranging terms gives

$$p'(q^d + Q_{-i})q^d + p'(\tilde{q})\tilde{q} = p(\tilde{q}) - p(q^d + Q_{-i}) \quad (5)$$

It is clear that equation (5) is not satisfied for any  $\tilde{q} < q^d$ . This means that with a two-part tariff contract the patentee cannot implement an outcome that is more profitable than the deterrence outcome. Furthermore, it is easy to show that the equation has a solution for a  $\tilde{q}$  such that  $q^d + Q_{-i} > \tilde{q} > q^d$ . With the help of a two-part tariff contract the patentee forecloses the market through a single license, however it must induce the production of a quantity that is larger than the simple commitment entry deterrence quantity.

Let us now briefly show that it is not profitable to distribute more than a single license. We will prove this for the case of  $L = 2$ . A simple extension to a general number of licenses easily follows. Let the induced quantities for licensee 1 (licensee 2) be  $\tilde{q} - a$  ( $a$ ) on the equilibrium path, and  $q^d - b$  ( $b$ ) off the equilibrium path, for  $a > 0, b > 0$ . The first-order-conditions for the two licensees are similar to those above, and when added together give

$$p'(q^d + Q_{-i})q^d - p'(\tilde{q})\tilde{q} = 2 [p(\tilde{q}) - p(q^d + Q_{-i})]. \quad (6)$$

Comparing equations (5) and (6) one sees that the latter will be satisfied for a larger  $\tilde{q}$ . With two licensees the patentee forecloses the market by collectively inducing a larger



quantity of output and by incurring twice the entry costs. Note that the coefficient in front of the term on the right hand side of equation (6) gives the number of licensees, so  $\tilde{q}$  increases monotonically in  $L$ . Therefore it is not optimal to choose more than a single licensee when contracts are limited to two-part tariffs.

## 4 Welfare Comparisons

The comparison of the market outcomes from the preceding sections according to some generally accepted welfare criteria can be summarized by one trade-off: While the availability of more complete or sophisticated contracts enable the patentee to achieve market dominance and a monopoly position, the existence of entry costs and non-decreasing returns to scale production technology points to efficiency gains from market concentration. It is in general not possible to reach a conclusion regarding the social (un)desirability of complex contractual forms.

When the patentee can employ contracts that induce the licensees to commit to an output function that is conditional on either the number of entrants or on market price and own quantity, the monopoly output will be produced by a single firm in equilibrium. On the other hand, when the most sophisticated contract that is available is one that allows the licensees to commit to own quantities only, then depending on the magnitude of fixed entry costs, either the monopoly output will be jointly produced by two firms, or the larger market deterrence quantity will be produced by a single firm. So for sufficiently low fixed entry costs, total surplus is unambiguously lower when the patentee has only ‘less powerful’ contracts in its arsenal. With high enough entry costs, however, total surplus is unambiguously greater as a larger quantity than the monopoly output is produced by a single firm. The comparison is more clear with simple quantity forcing agreements. The equilibrium outcome in this case is one in which a single licensee produces the deterrence quantity. This is strictly preferable to the production of the monopoly output by one or more licensees.

With this last result in mind, it is perhaps not surprising that with ‘less powerful’ contracts the market outcome is superior from a total surplus perspective. However this logic need not apply to the comparison of welfare with contracts to those without. For such a comparison one first needs to derive the market equilibrium for the case where the innovator is unable to (or is not allowed to) license its product, and hence, has to produce it on its own. Without contracts it is obvious that the innovator no longer has any commitment power and has to engage in simultaneous quantity competition with the other firms.

In order to simplify the comparisons, let us here assume that the number of firms is continuous. The number of active firms in equilibrium will be given by the zero-profit-condition  $(P(Q_n^c) - c)q_i^c = F$ , where  $Q_n^c$  is the total Cournot equilibrium quantity with  $n - 1 \geq 1$  firms that have a marginal cost of  $c$  and a single firm (the innovator) with a marginal cost of  $c - \delta$ , and  $q_i^c$  is the Cournot equilibrium quantity of one of the  $n - 1$  firms with higher marginal cost. We know from the preceding section that with free entry the total market output will be exactly equal to the deterrence quantity, as long as the zero-profit-condition of the last entrant is satisfied. In other words,  $Q_n^c = q^d$ . Comparing the outcomes under non-conditional quantity forcing contracts with that under no contracts, the only difference in total surplus comes from the greater number of active firms with no contracts. It is then clear that the outcome under non-conditional quantity forcing contracts is socially preferable. However the outcome with no contracts is not easily comparable to that with conditional contracts. Even though with conditional contracts total output is unambiguously lower ( $q^m < q^d$ ), one also has to consider the savings on fixed costs due to the smaller number of firms and the savings on production costs because a larger output is produced with a lower marginal cost. Unfortunately, without further restrictions in our model it is not possible to reach additional conclusions.

**Corollary 1** *The market equilibrium with non-conditional quantity forcing contracts is socially preferable over those with conditional contracts and with no contracts.*

This result highlights the difficulty for a policymaker, for instance a competition authority, of evaluating the merits of different contractual arrangements. Even though with certain type of contracts the market is completely closed to entry, the outcome is preferable to one where the patentee is unable to sign contracts with licensees. Commitment leads to higher market concentration but also to higher efficiency. Additionally, it is clear that with contracts the incentives to innovate are greater, as the returns are higher.

Our welfare discussion has so far focussed on static efficiency. The usual trade-off for dynamic efficiency is between providing incentives to innovate through a patent granting monopoly rights versus a distortion in allocative efficiency that results from the monopoly. Let us briefly argue why this trade-off might be different in this context. Suppose that there is an additional initial stage to our model, in which the innovator decides how much to invest in research for the new technology. Higher investment deterministically increases  $\delta$ , the cost reduction of the new technology. Within our model, patenting the new technology gives the innovator the possibility to write licensing contracts, which in turn gives him the power to monopolize the market given sufficiently complete contracts. However, the incentives to invest in a cost reduction does not increase when the market

power from the contract increases. Formally, the value of the cost reduction is  $\delta q$  where  $q$  is the equilibrium quantity the licensees produce. The equilibrium quantity decreases in the market power. In particular, two-part tariffs yield a larger quantity, and thus, larger incentives to invest in cost reduction than fully conditional contracts that yield the monopoly outcome.

## 5 Conclusion

The licensing literature, as well as the perhaps much larger vertical relations literature, mostly assumes simple contractual arrangements between firms and reaches conclusions without explicitly acknowledging the role contractual flexibility plays in the results. In this paper we show that if one places no a priori restrictions on contractual forms (e.g. payments have to be two-part tariffs) market outcomes will change drastically.

Another a priori restriction that is too common in the literature concerns the availability of market entry. Limiting the number of firms in a market without further explanation or justification is ad hoc, and as is shown here, can lead to sharply different results than when no such assumption is made. Our model is also highly general in the sense that we refrain from putting any restrictions on market demand.

In the context of a cost reducing innovation and homogenous goods competition our paper arrives at two results: First, when the patentee can employ contracts that can condition on any relevant market variables such as entry or price, it will achieve the maximum industry profit (the monopoly profit) by licensing its innovation to a single firm. Second, when the patentee can only employ contracts that condition on the quantities of the licensees, then depending on the magnitude of entry costs, it will either deter the entry of all other firms by enforcing a high enough quantity on a single licensee, or it will use two licensees to jointly produce the monopoly output. Our results are somewhat extreme in the sense that with only a single licensing contract the patentee can completely close the market to entry. In this respect they highlight the very strong and perhaps unrealistic commitment power that observable, non-renegotiable contracts give to the contracting parties.

From a social welfare point of view it is not easy to dismiss more sophisticated, conditional contracts as harmful. Although more sophisticated contracts increase market concentration (they lead to the monopoly outcome), there are efficiency gains to take into account. One interesting result is that with simple quantity forcing contracts total surplus is higher compared to the case where the patentee has no contracts available, as the total industry output remains unchanged but there are savings on entry and production costs.

There is certainly more work to be done regarding the use of other contractual forms in this setup. This is left for future work.

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