

Bargaining on the Sale of a New Innovation in the Presence of Potential Entry

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February 25, 2015

Abstract

We consider an industry with one incumbent and many potential entrants. Initially the high entry cost does not enable a profitable entry. Suppose an outside innovator holds a patent on a technology that eliminates the entry cost but has a marginal cost at least as high as the current one. The innovator wishes to sell his intellectual property (IP) to the incumbent, through bargaining. Even though the technology itself is useless for the incumbent, he may purchase the IP to limit or exclude further entry. The innovator may sell a few licenses to new entrants before approaching the incumbent. This on one hand reduces the total industry profit but enables a better credible threat on the incumbent and hence may increase the innovator's payoff. A licensing contract with an entrant specifies the license fee together with the maximum number of licenses that can be sold. The contracts are signed sequentially and they are bound by previous commitments. The firms are engaged in Cournot competition in the last stage. It is shown that depending on the marginal cost of the new technology and on the bargaining power of the innovator relative to that of the incumbent, there are three types of subgame perfect Nash equilibrium (SPNE): (i) the innovator sells first a license to one entrant before selling his IP to the incumbent. The incumbent then puts the technology on the shelf to exclude further entry. (ii) the innovator sells one license to an entrant before selling the IP to the incumbent. The incumbent then licenses the new technology to one additional entrant and (iii) the innovator sells the IP directly to the incumbent who then puts the technology on the shelf.

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1 Introduction

We consider a single product monopoly market with many potential entrants that currently can not enter the market due to a large entry (or fixed) cost. An outside innovator comes along with a new technology that eliminates the entry cost but with a marginal cost which is at least as high as that of the monopoly. The innovator wishes to sell his intellectual property (IP) to the incumbent who in turn is interested in limiting or excluding future competition, or even licensing the new technology to more entrants.

The innovator may sell a few licenses in a sequence to a number of new entrants before bargaining with the incumbent. A licensing contract with an entrant specifies the license fee together with the maximum number of licenses that can be sold. The contracts are signed sequentially and they have to be consistent with each other in the sense that any commitment on the number of licensees in one contract can not be violated in a future contract. The competition between potential entrants allows the innovator to offer each one of them a take-it-or-leave-it contract. The incumbent and new entrants are involved in a Cournot competition in the last stage.

Licensing his technology to some entrants before approaching the incumbent, while reducing the total industry profit, allows the innovator to credibly increase the threat on the incumbent (in case their negotiation fails). To illustrate this point, suppose that demand for the product is linear. It can be easily verified that after selling t licenses ($t \geq 0$) before approaching the incumbent, the innovator's optimal number for subsequence licensees if the bargaining fails is $t + 2$. That is, if the innovator approaches the incumbent first and their negotiation fails he will credibly sell a total of 2 licenses. But if he sells one license before approaching the incumbent then his threat is to sell another 3 licenses if negotiation fails. The innovator faces a tradeoff: on one hand the more licenses he sells prior to the negotiation with the incumbent the less is the total industry profit to be allocated, but on the other hand the higher is the threat on the incumbent.

The innovator and the incumbent bargain on the surplus which is the difference between (i) the optimal total industry profit in case an agreement is reached, which consists of the Cournot profits of the first licensees, the incumbent and possible future licensees¹ and (ii) the total payoffs of the two negotiators in case the bargaining fails. It is assumed that this surplus is allocated in proportion β , $0 \leq \beta \leq 1$ to the innovator. If $\beta = 1/2$ the outcome coincides with the Nash bargaining solution.

We characterize the subgame perfect Nash equilibrium (SPNE) in pure strategies as a

¹It is possible that the incumbent after purchasing the IP can profit from selling additional licenses himself.

function of two parameters: the relative bargaining power β and the marginal cost of the new technology. The SPNE is characterized by a partition into three regions of the two dimensional space of parameters.

In the first region, the innovator has a relatively low bargaining power and his technology is relatively inefficient. In this region the innovator sells a license to one entrant before selling the IP to the incumbent who then puts it on the shelf and excludes further entry.

In the second region, the innovator has a relatively low bargaining power and the technology is relatively efficient. In this region the innovator sells first a license to one entrant before selling the IP to the incumbent. The incumbent then sells one additional license to another entrant. In the third region, the innovator has sufficiently high bargaining power. The innovator approaches the incumbent first and sells him the IP. The incumbent does not use it and put it on the shelf. Note that when the innovator has a higher bargaining power, he can obtain a bigger share of the total industry profit. Thus the benefit he can obtain by inducing more competition (and hence increasing the threat on the incumbent) does not compensate for the loss of shrinking the industry profit.

It is assumed that once meeting with the innovator, the incumbent has the power to commit to not meeting the innovator again. It is shown here that it is of his best interest to exercise this power.

2 The Model: Description and Results

2.1 Description of the model

Consider an industry with one monopoly incumbent that produces a single good with a constant marginal cost c . The total demand is assumed to be $q = a - p$. There are many identical potential entrants that are unable to enter the market due to the high entry cost. An innovator holds a patent that eliminates the entry cost but with a larger marginal cost $c + \epsilon$, $\epsilon \geq 0$. If entrants get access to the new technology they will compete with the incumbent in an asymmetric Cournot competition. The outcome depends on the number, b , of new entrants having the access to the new technology. Denote by $\pi_0(b)$ and $\pi_e(b)$ the Cournot profits of the incumbent and an entrant, respectively.

In the first stage, the innovator approaches in sequence t potential new entrants, at his choice. Each potential entrant in the sequence is offered a contract of the form (α_i^1, δ_i^1) , $i = 1, \dots, t$, where α_i^1 is an upfront license fee and δ_i^1 is a commitment of the innovator to sell no more than δ_i^1 licenses in total. Contracts must be consistent with each other in the sense that the terms in one contract can not violate previous contracts. Therefore $\delta_1^1 \geq \dots \geq \delta_t^1$

must hold.

In the second stage, the innovator and the incumbent bargain on the surplus which is the difference between (i) the optimal total industry profit in case an agreement is reached, which consists of the total fee collected from the first t licensees and the Cournot profits of the incumbent and future licensees and (ii) the total payoffs of the two negotiators in case the bargaining fails.

In the third stage after the completion of the bargaining stage, the owner of the IP chooses the number of additional licenses to be sold. In the last stage the incumbent and the entrants are engaged in a Cournot competition. Let G be the game described above. The payoffs of the players in G are described next.

Suppose that k is the number of new entrant licensees. Let $x = \epsilon/(a - c)$. The Cournot profit of the incumbent and each licensee is given by

$$\pi_0(k) = (a - c)^2 \left(\frac{1 + kx}{k + 2} \right)^2 \quad (1)$$

and

$$\pi_e(k) = (a - c)^2 \left(\frac{1 - 2x}{k + 2} \right)^2 \quad (2)$$

Under the assumption that the number of potential entrants is large and their opportunity cost is zero, any entrant will pay his entire Cournot profit for the license.

The innovator and the incumbent bargain on the largest "cake" possible given the t licenses that have already been sold. The innovator brings to the table the total fee $\sum_{i=1}^t \alpha_i^1$ from the first t licensees and the incumbent brings to the table the maximum future profits possible if he purchases the IP. If an agreement was reached, the incumbent who is the new owner of the IP will choose the number $m = m(x, t)$ of licenses to sell (provided that no previous contract is violated) which maximizes his Cournot profit together with the Cournot profits he will collect from his future licensees. Namely

$$m(x, t) = \underset{m \leq \delta_t^1, m \in \mathbb{N}_0}{\operatorname{argmax}} [m\pi_e(m + t) + \pi_0(m + t)] \quad (3)$$

where $\mathbb{N}_0$ is the set of non negative integers. Let

$$\gamma_{inc} = m(x, t)\pi_e(m(x, t) + t) + \pi_0(m(x, t) + t) \quad (4)$$

be the part of the cake that will be provided by the incumbent. The total cake is

$$v = \sum_{i=1}^t \alpha_i^1 + \gamma_{inc} \quad (5)$$

Given the t licenses that were sold prior to the bargaining stage, if negotiation fails, the innovator will choose the optimal number of subsequence licensees $n = n(t)$ (again, provided that no previous contract is violated). Namely

$$n(t) = \operatorname{argmax}_{n \leq \delta_t^1, n \in \mathbb{N}_0} n\pi_e(t+n) \quad (6)$$

It can be easily verified that $n(t)$ (as opposed to $m(x,t)$) does not depend on x . Let

$$\gamma_{inn} = n(t)\pi_e(t+n(t)) \quad (7)$$

be the fee collected by the innovator from the $n(t)$ licensees if negotiation fails. Therefore the disagreement payoffs (d_1, d_2) for the innovator and incumbent respectively are

$$d_1 = \sum_{i=1}^t \alpha_i^1 + \gamma_{inn} \quad (8)$$

and

$$d_2 = \pi_0(t+n(t)) \quad (9)$$

Let

$$s = v - (d_1 + d_2) \quad (10)$$

It is assumed that if $s \geq 0$ an agreement will be reached where the innovator and the incumbent each obtains a proportion of the surplus s together with their disagreement payoff. Suppose that the relative bargaining power of the innovator and the incumbent are β and $1 - \beta$ respectively where $0 \leq \beta \leq 1$. Their payoffs in case $s \geq 0$ are

$$\pi_{inn} = \beta s + d_1 \quad (11)$$

$$\pi_{inc} = (1 - \beta)s + d_2 \quad (12)$$

When $\beta = 0.5$, their payoffs coincide with the Nash bargaining payoff.

To sum up, the payoff of the innovator is π_{inn} if he reaches an agreement with the incumbent and it is d_1 otherwise. The payoff of the incumbent is π_{inc} if an agreement is reached and d_2 otherwise. The payoff of each one of the first t entrants is $\pi_e(t+m(x,t)) - \alpha_i^1$

if an agreement is reached and $\pi_e(t + n(t)) - \alpha_i^1$ otherwise. All other licensees obtain zero.

As we show in the next section, in any SPNE $s \geq 0$ and hence an agreement between the two negotiators is always reached. In equilibrium, each of the first t entrants will pay the innovator their entire Cournot profit. Namely $\alpha_i^1 = \pi_e(m(x, t) + t)$ $i = 1, \dots, t$. The innovator then maximizes over t his payoff π_{inn} where

$$\begin{aligned} \pi_{inn}(x, \beta, t) = \beta[m(x, t)\pi_e(m(x, t) + t) + \pi_0(m(x, t) + t) - (n(t))\pi_e(t + n(t)) - \pi_0(t + n(t))] \\ + t\pi_e(m(x, t) + t) + n(t)\pi_e(t + n(t)) \end{aligned} \quad (13)$$

The quantity commitments $\{\delta_i^1\}_{i=1}^t$ will be specified later.

2.2 Subgame Perfect Nash Equilibrium

We analyse the pure strategy subgame perfect Nash equilibrium of the game G . Recall that $x = \epsilon/(a - c)$. The region of x is limited to $[0, 1/2)$ since for $x \geq 1/2$, there is no profitable entry. We will characterize the equilibrium for all parameters $(x, \beta) \in A$ where

$$A = \{(x, \beta) | 0 \leq x < 1/2, 0 \leq \beta \leq 1\} \quad (14)$$

Denote

$$A_1 = \{(x, \beta) | 1/14 \leq x < 1/2, 0 \leq \beta < \frac{10(1 - 2x)}{3(2x + 3)}\} \quad (15)$$

$$A_2 = \{(x, \beta) | 0 \leq x < 1/14, 0 \leq \beta < \frac{3(1 - 2x)}{34x + 7}\} \quad (16)$$

and

$$A_3 = A \setminus (A_1 \cup A_2) \quad (17)$$

Our main result shows that there are regions where the innovator is best off selling one license before approaching the incumbent even though this reduces the total industry profit.

Theorem 1. *For all $(x, \beta) \in A$ there exists a unique SPNE outcome in pure strategies. It satisfies*

(i) *Suppose $(x, \beta) \in A_1$. The innovator sells first a license to one entrant before selling the IP to the incumbent. The incumbent does not sell any additional licenses. The entrant pays a license fee of $\pi_e(1)$ and $\delta_1^1 \geq 4$.*

(ii) *Suppose $(x, \beta) \in A_2$. The innovator sells first one license before selling the IP to the incumbent. The incumbent then sells one additional license. Each of the two entrants pays*

a license fee of $\pi_e(2)$ and $\delta_1^1 \geq 4$.

(iii) Suppose $(x, \beta) \in A_3$. The innovator approaches first the incumbent and sells him the IP. The incumbent puts the new technology on the shelf and excludes any entry.

The proof of Theorem 1 appears in the Appendix. Figure 1 below shows the results graphically. The regions EI , EIE and I in Figure 1 correspond to the equilibrium outcome described in (i), (ii) and (iii) respectively.

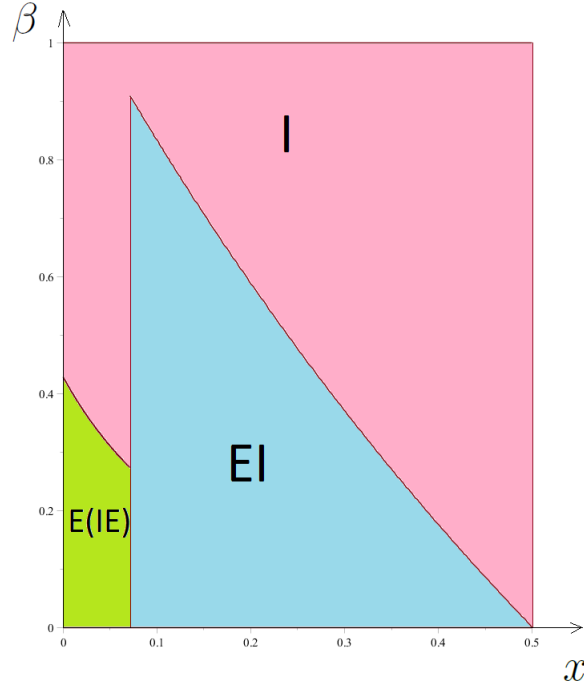


Figure 1: SPNE

3 Extension

3.1 Equilibrium when $\epsilon < 0$

Up till now we concentrated on the case where $\epsilon \geq 0$. A natural extension is to analyze the game G for $\epsilon < 0$. That is, the new technology not only eliminates the entry cost but also reduces the marginal cost.

In this case, if the incumbent purchases the IP, he will not put the new technology on the shelf but rather use it himself. Denote the number of new entrant firms by b . Let $k \in \{0, 1\}$ be an indicator. It is 1 if the incumbent uses the new technology and 0 otherwise. Let $\pi_0(k, b)$ and $\pi_e(k, b)$ be the Cournot profits of the incumbent and entrant, respectively.

Whenever $x < -1/b$, the incumbent is driven out of the market if he does not have an access to the new technology. It is easy to verify that the Cournot profits of the incumbent and the entrant are:

$$\begin{aligned}\pi_0(1, b) &= \pi_e(1, b) = (a - c)^2 \left(\frac{1+x}{b+2} \right)^2 \\ \pi_e(0, b) &= \begin{cases} (a - c)^2 \left(\frac{1+x}{b+1} \right)^2 & \text{if } x \leq -\frac{1}{b} \\ (a - c)^2 \left(\frac{1+2x}{b+2} \right)^2 & \text{if } x > -\frac{1}{b} \end{cases} \\ \pi_0(0, b) &= \begin{cases} 0 & \text{if } x \leq -\frac{1}{b} \\ (a - c)^2 \left(\frac{1-bx}{b+2} \right)^2 & \text{if } x > -\frac{1}{b} \end{cases}\end{aligned}$$

We plan to analyse this case similarly to the case where $\epsilon \geq 0$ even though it appears more challenging. In particular, it will be interesting to find out whether the innovator may benefit by selling licenses to entrants prior to the bargaining stage in order to increase his bargaining position.

APPENDIX

Proof of Theorem 1

Let

$$s(m) = \underbrace{m\pi_e(m+t) + \pi_0(m+t)}_{\text{part 1}} - \overbrace{(n(t)\pi_e(n(t)+t) + \pi_0(n(t)+t))}^{\text{part 2}} \quad (18)$$

Note that for $m = m(x, t)$, (18) is the net surplus (defined in (10)). Clearly $s(n(t)) = 0$ hence $s(m(x, t)) = \max_m s(m) \geq 0$. We conclude that if $m(x, t)$ is feasible (does not contradict previous contracts) then $s(m(x, t)) = v - (d_1 + d_2) \geq 0$ and an agreement between the innovator and the incumbent will be reached.

Since the contracts has to be consistent with each other, $m = n(t)$ is a feasible choice for the incumbent if and only if $\delta_t^1 \geq t + n(t)$. This will allow the incumbent selling an additional $n(t)$ licenses without violating the first t license contracts. Thus, we first analyse the case under the assumption $\delta_t^1 \geq t + n(t)$.

Suppose that t licenses were first sold. In the case negotiation fails, the innovator will maximise over n the profit of the subsequent licensees

$$n\pi_e(t+n) \quad (19)$$

Since

$$\frac{\partial [n\pi_e(t+n)]}{\partial n} = \frac{(a-c)^2(2x-1)^2(t+2-n)}{(t+n+2)^3}$$

(19) is maximized when $n = t + 2$. Thus $n(t) = t + 2$. That is, the innovator's credible threat on the incumbent is to sell additional $t + 2$ licenses.

Next, given the first t licenses and assuming an agreement has been reached, the incumbent chooses to sell additional m licenses where m is the maximizer of

$$M(m, t) = m\pi_e(m + t) + \pi_0(m + t) \quad (20)$$

Since

$$\frac{\partial[m\pi_e(m + t) + \pi_0(m + t)]}{\partial m} = \frac{(a - c)^2[m(2x - 1) + 8tx^2 - 6tx + 8x^2 + t - 4x]}{(m + t + 2)^3} \quad (21)$$

and since the right-hand side of (21) is decreasing in m , the solution of the FOC given t ($\frac{\partial[m\pi_e(m + t) + \pi_0(m + t)]}{\partial m} = 0$) is the maximizer of $M(m, t)$. It is easy to verify that the solution is $t(1 - 4x) - 4x$. However, it may not be a non-negative integer. Denote $s(x, t) = t(1 - 4x) - 4x$. If $s(x, t)$ is a non-negative integer then $m(x, t) = s(x, t)$. To find $m(x, t)$, note first that for $t = 0$, $s(x, 0) = -4x < 0$. Thus (20) is maximized for $m = 0$. Namely $m(x, 0) = 0$ for $0 \leq x \leq 1/2$.

For $t = 1$, $s(x, 1) = 1 - 8x < 1$ and hence $M(m, 1)$ is maximized either at $m = 0$ or at $m = 1$, depending on the value of x . Since

$$M(0, 1) - M(1, 1) = (a - c)^2[-(7/18)x^2 + (2/9)x - 1/72]$$

is negative for $0 < x < 1/14$ and it is positive for $1/14 < x < 1/2$, we have $m(x, 1) = 1$ when $0 < x < 1/14$ and $m(x, 1) = 0$ otherwise.

$$m(x, 1) = \begin{cases} 1 & 0 < x < 1/14 \\ 0 & 1/14 < x < 1/2 \end{cases}$$

For our proof we don't need to know explicitly the function $m(t)$ for $t \geq 2$. We will show that the payoff of the innovator is never maximized at $t \geq 2$, therefore only $m(x, 0)$ and $m(x, 1)$ are relevant. Let us deal next with the equilibrium strategy (choice of t) of the innovator.

Given (x, β) , the innovator chooses the t which maximizes his payoff

$$\pi_{inn}(x, \beta, t) = \overbrace{\beta[(m(x, t) + t)\pi_e(m(x, t) + t) + \pi_0(m(x, t) + t)]}^{\text{part 3}} + (1 - \beta)t\pi_e(m(x, t) + t) + \underbrace{(1 - \beta)n(t)\pi_e(n(t) + t) - \beta\pi_0(n(t) + t)}_{\text{part 4}} \quad (22)$$

The right-hand side of (22) is equivalent to the right-hand side of (13).

Given (x, β) , let

$$\bar{\pi}_{inn}(x, \beta) = \max\{\pi_{inn}(x, \beta, 0), \pi_{inn}(x, \beta, 1)\}$$

Simple calculation shows that in regions A_1 and A_2 (defined in (15) and (16)) $\pi_{inn}(x, \beta, 0) \leq \pi_{inn}(x, \beta, 1)$. But $\pi_{inn}(x, \beta, 0) \geq \pi_{inn}(x, \beta, 1)$ in region A_3 (defined in (17)). Namely, the innovator chooses $t = 1$ in region A_1 and A_2 , and $t = 0$ in region A_3 .

For every $m \in \mathbb{R}_+$ let

$$\begin{aligned} \pi(m, x, \beta, t) &= \beta[(m + t)\pi_e(m + t) + \pi_0(m + t)] + (1 - \beta)t\pi_e(m + t) \\ &\quad + (1 - \beta)n(t)\pi_e(n(t) + t) - \beta\pi_0(n(t) + t) \end{aligned} \quad (23)$$

By (22) $\pi_{inn}(x, \beta, t) = \pi(m(x, t), x, \beta, t)$. By the definition of $s(x, t)$, we have $\pi(m(x, t), x, \beta, t) \leq \pi(\max\{s(x, t), 0\}, x, \beta, t)$. Thus if

$$\pi(\max\{s(t), 0\}, x, \beta, t) < \bar{\pi}_{inn}(x, \beta) \quad (24)$$

holds for $t \geq 2$, we can conclude that in every SPNE $t \leq 1$. Inequality (24) can be illustrated by a 3-dimensional graph (to be sent upon request).

We complete the proof of Theorem 1 by showing that for no SPNE $\delta_t^1 < t + n(t)$. When $t = 0$, no contract is signed priori to the bargaining between the innovator and the incumbent, thus there is no constraint on the number of subsequent licenses. Suppose $t \geq 1$, let $b = \delta_t^1 - t$. Note that $b < n(t)$ since $\delta_t^1 < t + n(t)$. Denote $\hat{m}(x, t) = \min\{m(x, t), b\}$. The total new cake is now

$$\hat{v} = \sum_{i=1}^t \alpha_i^1 + \hat{m}(x, t)\pi_e(\hat{m}(x, t) + t) + \pi_0(\hat{m}(x, t) + t)$$

The disagreement payoffs are

$$\hat{d}_1 = \sum_{i=1}^t \alpha_i^1 + b\pi_e(t + b)$$

$$\hat{d}_2 = \pi_0(t + b)$$

The corresponding profit of the innovator is

$$\begin{aligned} \hat{\pi}_{inn}(x, \beta, t) = & \overbrace{\beta[(\hat{m}(x, t) + t)\pi_e(\hat{m}(x, t) + t) + \pi_0(\hat{m}(x, t) + t)]}^{\text{part 5}} + (1 - \beta)t\pi_e(\hat{m}(x, t) + t) \\ & + \underbrace{(1 - \beta)b\pi_e(t + b) - \beta\pi_0(t + b)}_{\text{part 6}} \end{aligned} \quad (25)$$

By definition, for $b \geq m(x, t)$, $\hat{m}(x, t) = m(x, t)$. In this case part 5 of (25) coincides with part 3 of (22). But part 6 of (25) is smaller than part 4 of (22). To see this note that $k\pi_e(k + t)$ is maximized for $k = n(t)$ and $\pi_0(k + t)$ is decreasing in k . As a result, the innovator is worse off by setting the constraint $m(t) \leq b < n(t)$.

Finally consider the case $b < m(x, t)$. Now $\hat{m}(x, t) = b$. If an agreement is reached, the surplus now is

$$\begin{aligned} \hat{v} - \hat{d}_1 - \hat{d}_2 &= \hat{m}(x, t)\pi_e(\hat{m}(x, t) + t) + \pi_0(\hat{m}(x, t) + t) - [b\pi_e(t + b) + \pi_0(t + b)] \\ &= b\pi_e(t + b) + \pi_0(t + b) - [b\pi_e(t + b) + \pi_0(t + b)] = 0 \end{aligned} \quad (26)$$

Thus, the constraint $b < m(x, t)$ does not allow the innovator to obtain more than his disagreement payoff. We conclude that in every SPNE $b \geq n(t)$ must hold. Namely $\delta_t^1 \geq t + n(t)$.