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Abstract

We consider a contest in which one firm is a favourite as it initially has a cost advantage over rivals. Instead of taking the set of rivals as given, we consider the possibility that the favourite transfers the source of its advantage wholly or partially to a subset of rival firms. The result of this may be foreclosure of those firms that do not receive the cost reduction. We present conditions under which this transfer will be expected to occur, and show that the dominant firm will prefer to grant some rivals the maximum cost reduction even if a partial transfer can be made. Furthermore we consider the welfare properties of excluding some rivals. Applications include lobbying, patent races and access to essential infrastructure.

Keywords: Foreclosure, contest

JEL Classification: D21, L24

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1 Introduction

In a contest situation agents compete for a prize or a rent by making irretrievable outlays or efforts. The set of competitors is usually taken as fixed and a variety of design variations have been considered that affect the amount of effort supplied by contestants and their consequent expected profits. Examples are the structure of prizes (Clark and Riis, 1998; Moldovanu and Sela, 2001), the order of moves and commitment (Dixit, 1987; Perez-Castrillo and Verdier, 1992), the form of the contest success function (Hirshleifer, 1989; Nti, 2004; Amegashie, 2006), rent-sharing arrangements (Long and Vousden, 1987; Nitzan, 1991) and multiple rounds (Gradstein and Konrad, 1999).[1] Whilst the focus in these papers is how a designer (outside of the contest) can affect the outcomes and efforts of the participants, we consider a situation in which one of the participants can act in order to affect the contest arena. Specifically, we look at the case in which one firm has a smaller cost of making effort in the contest than rivals. Instead of taking this situation for granted, the low-cost firm can wholly or partially donate the source of its advantage to a subset of rivals with the intention of driving non-recipients from the market. In a lobbying application for example, the superior lobby may have the better contacts and can offer some of these to rivals; if the contest describes a patent race then the laboratory that is most efficient may loan out some of its researchers, or disclose some of its techniques. By doing this, the hope is that the remaining inferior competitors may pull out of the contest completely. Here there is a trade off since the superior firm reduces the number of rivals, which increases its own profit, but the remaining competitors are more efficient and this would drive profit down.

Previously, Baye et al (1993) have looked at the possible benefits to excluding some competitors in an all-pay auction; they noted that a player with more to gain from winning than other competitors can effectively "scare off" competitors, making it less likely that they will submit a positive bid. These authors presented conditions under which a contest designer can increase the expected total bid in the all-pay auction by excluding the strongest competitors. On a similar note, Amegashie (1999,

[1]This is by no means and exhaustive list of design possibilities nor the attached literature. The interested reader is referred to Congleton et al. (2008) and Konrad (2007).

2000) looks at rent-seeking in a Tullock (1980) contest in which competitors may have to compete in a preliminary round, or be subjected to shortlisting. He analyses how contest administrators can then affect the level of rent-seeking through different designs of the preliminary round or the shortlisting process. Our work deviates from previous papers in this field by not focusing on the exogenous design of contests, but we analyze the case in which one of the participants attempts to endogenously change the rules of the game. Specifically, we allow the firm that has the cost advantage in the rent seeking activity to "license" its advantage to a sub-set of the other, ex ante identical, firms.[2] We refer to this generally as a transfer of "rent-seeking technology", and give examples of this activity at the end of the general analysis. After the transfer of rent-seeking technology, there is competition according to a Tullock contest model where firms compete for a prize of exogenously given value.[3]

The main message from the paper is that foreclosure of a subset of firms may be the outcome even without restrictions on the licensing schemes. To transfer the cost reduction to a subset of rivals may be used as a tool to foreclose the non-license takers from the market. We demonstrate first that a firm that has a large advantage over its rivals will prefer to "go it alone", and not transfer its rent-seeking technology to others. When the initial cost advantage is smaller, the dominant firm will only make a transfer of its cost advantage if it can be used to foreclose some rival firms. The reason for this is that active outsiders (i.e. firms that do not obtain licenses) are a drain on the insiders' profit. Licensing only occurs if the licensor is able to foreclose all rival firms but the licensees, and trades are more likely the larger the number of players at the outset.

To check the robustness of the results, we open for the possibility that the superior firm can transfer an intermediate cost advantage to rivals (i.e. reducing the marginal cost of the contest activity to licensees, but still keeping it above that of the dominant actor). It turns out that the motive to foreclose is so strong that the superior firm would prefer to grant the greatest cost reduction possible since this

[2]Although we refer to this as licensing, we place no restrictions on the form of payment that may be made for access to the cost advantage in rent seeking.

[3]Huck et al. (2002) come closest to our focus on endogenizing the number of competitors in considering merger between rivals in a contest.

also forecloses as many rivals as possible.

Section 2 analyses the case in which only the only the whole cost reduction can be transferred, and Section 3 looks at the transfer of an intermediate cost reduction. Section 4 discusses the findings, and presents policy implications in different applications of the analysis.

2 The model

There are $n+1$ firms that compete for a prize of value V by making a sunk investment of some kind. Let firm 0 have a marginal cost of investment equal to 1. All other firms $j = \{1, .., n\}$ have a marginal cost $c > 1$. This cost difference can be thought of as differences in rent-seeking technology. Investments are denoted by $\widehat{x}_0$ and $\widehat{x}_j$ and are irretrievable. The probability (p) that a firm wins is equal to its investment relative to the sum of investments:

$$\begin{aligned} p_0 &= \frac{\widehat{x}_0}{\widehat{x}_0 + \sum_{s=1}^{n} \widehat{x}_s} \qquad (1) \\ p_j &= \frac{\widehat{x}_j}{\widehat{x}_0 + \sum_{s=1}^{n} \widehat{x}_s}, \quad j = \{1, .., n\} \end{aligned}$$

This formulation has been often used in the contest literature, following the seminal work by Tullock (1980)[4].

2.1 Benchmark case

When each firm uses its initial rent-seeking technology with the marginal costs outlined above, the expected payoffs are given by

[4] For many contest type applications of this function see Konrad (2007).

$$\begin{aligned}
\widehat{\pi}_0 &= \frac{\widehat{x}_0 V}{\widehat{x}_0 + \sum_{s=1}^n \widehat{x}_s} - \widehat{x}_0 \\
\widehat{\pi}_j &= \frac{\widehat{x}_j V}{\widehat{x}_0 + \sum_{s=1}^n \widehat{x}_s} - c\widehat{x}_j, j = \{1, ..., n\}
\end{aligned}$$

First-order conditions defining an interior maximum for $\widehat{x}_0$ and $\widehat{x}_j$ are given by

$$\begin{aligned}
\frac{\sum_{s=1}^n \widehat{x}_s V}{(\widehat{x}_0 + \sum_{s=1}^n \widehat{x}_s)^2} - 1 &= 0 \\
\frac{\widehat{x}_0 + \sum_{s\neq j} \widehat{x}_s V}{(\widehat{x}_0 + \sum_{s=1}^n \widehat{x}_s)^2} - c &= 0, j = \{1, ..., n\}
\end{aligned}$$

Equilibrium investments and expected payoffs are then easily verified to be

$$\begin{aligned}
\widehat{x}_0^* &= \frac{Vn(n(c-1)+1)}{(cn+1)^2} \\
\widehat{x}_j^* &= \frac{Vn}{(cn+1)^2}, \quad j = \{1, ..., n\} \\
\widehat{\pi}_0^* &= \frac{(n(c-1)+1)^2 V}{(cn+1)^2} = \widehat{x}_0^*(c - 1 + \frac{1}{n}) \qquad (2) \\
\widehat{\pi}_j^* &= \frac{V}{(cn+1)^2} = \frac{\widehat{x}_j^*}{n}, \quad j = \{1, ..., n\} \qquad (3)
\end{aligned}$$

$$W \equiv \widehat{\pi}_0^* + n\widehat{\pi}_j^* = \frac{(n(c-1)+1)^2 V}{(cn+1)^2} + n\frac{V}{(cn+1)^2}$$

where W is total welfare. The form of $\widehat{\pi}_0^*$ emphasizes the two sources of profit that firm 0 has in this model; profit increases the larger the cost advantage that firm 0 has compared to others ($\frac{\partial \widehat{\pi}_0^*}{\partial c} > 0$), and the lower the number of rivals that compete for the prize ($\frac{\partial \widehat{\pi}_0^*}{\partial n} < 0$).

2.2 Transfer of rent seeking technology

Suppose now that firm 0 can license its rent-seeking technology to $k \leq n$ of the other firms for a price of t. Hence, with licensing we have $k+1$ firms with marginal cost of rent-seeking equal to 1, and $n-k$ with marginal cost c. Denote the set of the k *ex ante* outsiders with access to the superior rent-seeking technology by set T and the $n-k$ without as set NT. We assume that there are no restrictions on the licensing schemes. Although the price t can be both positive and negative, the licensees in the present model will benefit from the reduction in marginal cost of participating in the contest and are therefore prepared to pay a positive price $t > 0$. The expected payoffs of firm 0, $j \in T$, and $i \in NT$ are then given by

$$\begin{aligned}
\pi_0 &= \frac{x_0 V}{x_0 + \sum_{s \in T} x_s + \sum_{v \in NT} x_v} - x_0 + kt \\
\pi_j &= \frac{x_j V}{x_0 + \sum_{s \in T} x_s + \sum_{v \in NT} x_v} - x_j - t, \ j \in T \\
\pi_i &= \frac{x_i V}{x_0 + \sum_{s \in T} x_s + \sum_{v \in NT} x_v} - c x_i, \ i \in NT
\end{aligned} \tag{4}$$

An interior equilibrium for investments is characterized by the following first-order conditions:

$$\begin{aligned}
\frac{\partial \pi_0}{\partial x_0} &= \frac{\left(\sum_{s \in T} x_s + \sum_{v \in NT} x_v\right) V}{\left(x_0 + \sum_{s \in T} x_s + \sum_{v \in NT} x_v\right)^2} - 1 = 0 \\
\frac{\partial \pi_j}{\partial x_j} &= \frac{\left(x_0 + \sum_{s \neq j \in T} x_s + \sum_{v \in NT} x_v\right) V}{\left(x_0 + \sum_{s \in T} x_s + \sum_{v \in NT} x_v\right)^2} - 1 = 0, \ j \in T \\
\frac{\partial \pi_i}{\partial x_i} &= \frac{\left(x_0 + \sum_{s \in T} x_s + \sum_{v \neq i \in NT} x_v\right) V}{\left(x_0 + \sum_{s \in T} x_s + \sum_{v \in NT} x_v\right)^2} - c = 0, \ i \in NT
\end{aligned} \tag{5}$$

The problems that player 0 and each member of T have to solve are identical, as is the maximization problem for each $i \in NT$. Posit then that $x_0 = x_j \equiv x \ \forall \ j \in T$ and $x_i \equiv y \ \forall \ i \in NT$. Then (5) can be rewritten as

$$\begin{aligned}
\frac{(kx+(n-k)y)\,V}{((k+1)x+(n-k)y)^2}-1 &= 0 \\
\frac{((k+1)x+(n-k-1)y)\,V}{((k+1)x+(n-k)y)^2}-c &= 0,\ i\in NT
\end{aligned} \tag{6}$$

From these two equations, the following relative relationship between x and y emerges:

$$x=\frac{(n-k)(c-1)+1}{1+k(1-c)}y \tag{7}$$

The numerator in (7) is always positive and the denominator is positive for

$$\frac{1}{c-1}>k \tag{8}$$

Since an equilibrium involving some transfer of rent-seeking technology in which all n firms are active has $k\geq 1$ we can state the following result immediately.

Proposition 1 *There is no interior pure strategy Nash equilibrium involving the transfer of rent-seeking technology for $c>2$, given that all firms are active.*

When the rivals are at a strong disadvantage ($c>2$) it does not pay for the efficient firm to allow others to become more efficient whilst at the same time having some players participating that do not pay a licensing fee to firm 0.

2.2.1 Transfer without foreclosure

Suppose now that (8) is fulfilled, i.e., $c\in(1,2]$, so that all firms have positive investment in equilibrium irrespective of their type of rent-seeking technology; we proceed to characterize the pure strategy Nash equilibrium. Using (7) in (6) gives the following equilibrium investments:

$$
\begin{aligned}
x^* &= \frac{Vn((n-k)(c-1)+1)}{((n-k)c+k+1)^2} \\
y^* &= \frac{Vn(1+k(1-c))}{((n-k)c+k+1)^2}
\end{aligned}
\tag{9}
$$

Inserting (9) into (4) gives the equilibrium expected payoffs as

$$
\begin{aligned}
\pi_0^*(n,k) &= \frac{V((n-k)(c-1)+1)^2}{((n-k)c+k+1)^2} + tk \\
\pi_j^*(n,k) &= \frac{V((n-k)(c-1)+1)^2}{((n-k)c+k+1)^2} - t, j \in T \\
\pi_i^*(n,k) &= \frac{V((k(c-1)-1)^2}{((n-k)c+k+1)^2}, i \in NT
\end{aligned}
\tag{10}
$$

Licensing of the more efficient rent-seeking technology is profitable for 0 if $\pi_0^* \geq \widehat{\pi}_0^*$, and those who are offered the new technology wish to buy as long as $\pi_j^* \geq \widehat{\pi}_j^*$ from (3).

A licensing agreements is feasible if it is in the interest of both the licensor and the licensees. In order to look at the feasibility of licensing agreements, consider the payoff of the group of "insiders", i.e. firms that have the best rent-seeking technology consisting of firm 0 and $j \in T$. The aggregate profit of this group increases after technology transfer if

$$
\pi_0^*(n,k) + k\pi_j^*(n,k) > \widehat{\pi}_0^* + k\widehat{\pi}_j^* \tag{11}
$$

since the licensing fee is just an internal transfer within the group. Without considering the licensing fee, it is easy to verify that 0 gets a lower payoff following transfer of the rent-seeking technology, and the other insiders experience an increase. The licensor will not accept to share its cost advantage without side payment, and the licensees are willing to pay a positive price for access to the better rent-seeking technology, which implies that feasibility requires a transfer to the licensor.

If (11) is satisfied, it is possible to compensate firm 0 adequately for the reduction in expected payoff. Using (10), (2) and (3), (11) is satisfied as long as

$$n \geq k > \frac{2\,(cn+1)\,(-n+cn+1)}{(c-1)\,(n(2c-1)+2)} \tag{12}$$

A necessary condition for this to hold is that the interval is defined, i.e.

$$\begin{aligned} n - \frac{2\,(cn+1)\,(-n+cn+1)}{(c-1)\,(n(2c-1)+2)} &> 0 \Rightarrow \\ \frac{-(n^2(c-1)+2(1+cn))}{(c-1)\,(n(2c-1)+2)} &> 0 \end{aligned}$$

which clearly cannot hold since $(n^2(c{-}1){+}2(1{+}cn)) > 0$ and $(c-1)\,(n(2c-1)+2) > 0$ since $c > 1$.

Hence we see that (12) cannot be satisfied. This means that by selling licences to k firms, while the remaining $n-k$ firms are still active in the market, leads to a reduction in the total profit of the insiders. Hence, we have the following result:

Proposition 2 *There is no feasible licensing agreement involving the transfer of the superior rent-seeking technology to k firms given that the $n-k$ firms are active.*

This result implies that a motive for transferring the rent-seeking technology to others may be foreclosure of non-recipients, a case to with we now turn.

2.2.2 Transfer with foreclosure

Allowing non-license takers to remain active is a drain on the profits of the insider group. Assume then that k is set so that $y^* = 0$, i.e.

$$n > k \geq \frac{1}{c-1} \tag{13}$$

Note that there are now only $k+1$ players in total (0 and the k licensees). This means that the expressions in (9) have to be adjusted accordingly by setting $y^* = 0$ and $n = k$ in x^* so that the amount of investment in the pure strategy Nash equilibrium is:

$$x^f = \frac{k}{(1+k)^2}V$$

with expected total payoffs to the group of $k+1$ insiders

$$\Pi^f = \frac{V}{k+1} \tag{14}$$

with each insider earning $\pi^f = \frac{V}{(k+1)^2} - t$ and firm 0 earning $\pi_0^f = \frac{V}{(k+1)^2} + tk$. Given that (13) is fulfilled, trade of licenses either at a positive or negative price is now feasible if total payoffs to the insiders (firm 0 and the k licensees) are higher with than without license transfer:

$$\Delta\Pi = \Pi^f - \left(\widehat{\pi}_0^* + k\widehat{\pi}_j^*\right) \geq 0 \tag{15}$$

Feasibility of trade in licenses at a positive price requires that $\pi^f > \widehat{\pi}_j^*$ for each of the k insider firms, which is always satisfied since $cn > k$.

Given that $\Delta\Pi \geq 0$, firm 0 will choose the number of licenses, k, to make Π^f as large as possible in relation to the outside option of the licensees ($k\widehat{\pi}_j^*$). This would imply that the total value added of licensing with foreclosure is maximized. Without any restrictions on the price structure or price level, a transfer payment between the licensees and the licensor can be set up to allow the licensor to capture the value added. Hence, firm 0 sets k that maximizes the following

$$\Pi_0^f = \Pi^f - k\widehat{\pi}_j^* = \frac{V}{(k+1)} - k\frac{V}{(cn+1)^2} \tag{16}$$

Since Π_0^f is decreasing in k, the lowest value of this parameter will be chosen, given that the foreclosure condition in (13) holds. Hence, firm 0 will set $k^f = \frac{1}{c-1}$ to achieve foreclosure of the $n-k$ firms. Inserting k^f into (15), trade is feasible, ($\Delta\Pi \geq 0$), as long as

$$n^2c(c-1)^2 + 1 - 2c > 0 \tag{17}$$

We need also that $n > k^f = \frac{1}{c-1}$. It is easily verified that this is true when (17) is satisfied. From (17) we see that trades are more likely to be feasible the larger is n. Solving (17) delineates feasible trades, and we define n^f as the critical level of n that ensures feasible trades:

$$n > n^f = \sqrt{\frac{2c-1}{c(c-1)^2}} \tag{18}$$

Consequently, the larger is the number of potential firms, n, the more likely is the feasibility of trade in licenses. It is straightforward to show that the critical level of n^f is lower the higher is the marginal cost of effort for the outsiders, since $\partial n^f / \partial c < 0$ for $c \in (1, 2]$

$$\frac{\partial n^f}{\partial c} = -\frac{(4c^2 - 3c + 1)}{2c^2(c-1)^3 \sqrt{\frac{2c-1}{c(c-1)^2}}} < 0$$

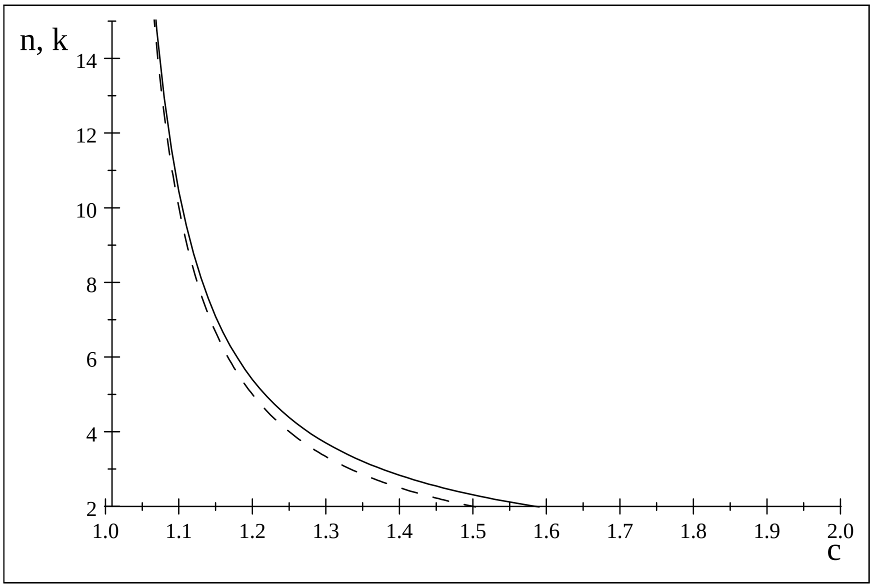

Figure 1: Foreclosure level k^f and the feasibility requirement n^f: n^f (whole line), k^f (dashed line) for $n \geq 2$

For the sake of the argument, we concentrate on $n \geq 2$, so that at least one firm will be foreclosed. When c approaches 2, n^f approaches $\frac{1}{2}\sqrt{6} < 2$, such that trades will always be feasible. From (18) we find that $n^f = 2$ if $c \approx 1.59$. Consequently, if

$c \in (1.59, 2]$, trade is feasible for all $n \geq 2$. In contrast, when c approaches 1, trades will not be feasible.

We thus state the following result:

Proposition 3 *Licensing to k firms in order to foreclose the $n-k$ firms from the contest increases the total expected payoffs to the insiders as long as $n > n^f$, where n^f is decreasing in c.*

While trades are feasible when (15) is fulfilled, the condition that ensures that trade increases welfare is given by

$$\Delta W = \Pi^f - \left(\widehat{\pi}_0^* + n\widehat{\pi}_j^*\right) \geq 0 \tag{19}$$

Since $n > k$, as long as $n > n^f$, it follows that $\Delta W \geq 0$ is a stronger condition than $\Delta \Pi \geq 0$. Thus, the set of outcomes that involves feasibility of licensing is larger than the set of outcomes that is socially desirable. We insert for k^f into (14), and total expected payoffs to the insiders in the foreclosure case becomes:

$$\Pi^f(k^f) = \frac{V(c-1)}{c}$$

The condition that ensures that foreclosure increases welfare (19) may then be rewritten as

$$\Delta W = \frac{V(c-1)}{c} - \left(\frac{V\left(n^2\left(c^2-2c+1\right)+n\left(2c-1\right)+1\right)}{(cn+1)^2}\right) = \frac{V\left(c^2n^2-cn^2-cn-1\right)}{(cn+1)^2 c} \geq 0$$

It is easily verified that ΔW is an increasing function of n. Hence we can define n^w as the critical level of n that ensures that welfare increases:

$$n^w \equiv \frac{1}{2c(c-1)}\left(c + \sqrt{c(5c-4)}\right)$$

with welfare increasing for $n > n^w$.

Comparing the two critical levels of n, n^f and n^w, we first of all observe that n^w is strictly larger than n^f for all permissible parameter values. This implies that there are combinations of (n, c) such that license trading is feasible (with $n > n^f$), but where such trade is detrimental to welfare (with $n < n^w$). This is the area between the solid and dashed line in the figure below. As we observe from the figure, the area exists albeit not for a substantial set of parameter values. For most of the combinations of the parameters (n, c), feasible trade would also be welfare enhancing.

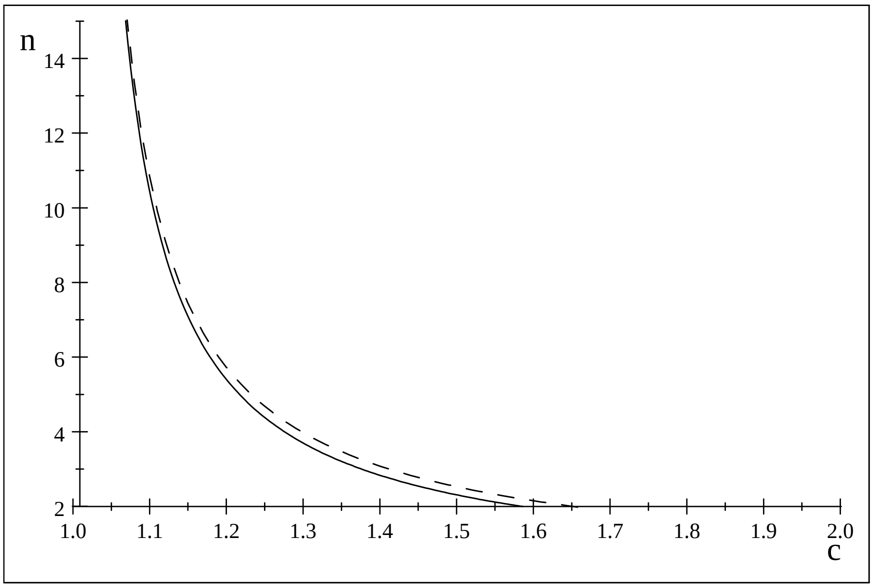

Figure 2: Feasible versus welfare enhancing trade (n^w dashed line, n^f whole line), $n \geq 2$

We also need to check that $n > k^f \equiv \frac{1}{c-1}$, or since $n^w > n^f$ that $n > \max\left\{k^f, n^f\right\}$ which is trivially satisfied for $c > 1$:

$$\begin{aligned} n^f - k^f &= \sqrt{\frac{2c-1}{c(c-1)^2}} - \frac{1}{c-1} \\ &= \frac{1}{(c-1)}\left(\sqrt{\frac{2c-1}{c}} - 1\right) > 0 \text{ for } c \in (1, 2] \end{aligned}$$

It is straightforward to show $\partial \Delta W / \partial c > 0$ and $\partial \Delta W / \partial n > 0$ for $c \in (1, 2]$. Hence welfare will increase most the more disadvantaged the rivals to 0, and the larger their initial number. Moreover, we have that $\Delta W > 0$ when c approaches 2, while $\Delta W < 0$ when c approaches 1.

3 Partial transfer or rent-seeking technology

To check the robustness of the results of the previous section, we now consider whether firm 0 may benefit from transferring a rent-seeking technology that is better than rivals have at the outset but that is not as efficient as the one used by firm 0. One may interpret this as transferring a rent-seeking technology of an intermediate quality, where quality becomes a choice variable for firm 0. Let us assume that k firms are allowed to acquire the rent-seeking technology that gives a marginal cost of investment of a, where $a \in [1, c]$, and $n - k$ still have the original marginal cost c. The first-order conditions are now given by:

$$
\begin{aligned}
\frac{\partial \pi_0}{\partial x_0} &= \frac{\left(\sum_{s\in T} x_s + \sum_{v\in NT} x_v\right) V}{\left(x_0 + \sum_{s\in T} x_s + \sum_{v\in NT} x_v\right)^2} - 1 = 0 \\
\frac{\partial \pi_j}{\partial x_j} &= \frac{\left(x_0 + \sum_{s\neq j\in T} x_s + \sum_{v\in NT} x_v\right) V}{\left(x_0 + \sum_{s\in T} x_s + \sum_{v\in NT} x_v\right)^2} - a = 0,\ j \in T \\
\frac{\partial \pi_i}{\partial x_i} &= \frac{\left(x_0 + \sum_{s\in T} x_s + \sum_{v\neq i\in NT} x_v\right) V}{\left(x_0 + \sum_{s\in T} x_s + \sum_{v\in NT} x_v\right)^2} - c = 0,\ i \in NT
\end{aligned}
\tag{20}
$$

Then we have the following equilibrium investments for each firm type (0, T, NT):

$$
\begin{aligned}
x_0(a) &= \frac{(cn - ck - n + ka + 1)\, Vn}{(cn - ck + ka + 1)^2} \\
x_T(a) &= \frac{(cn - ck + ka - na + 1)\, Vn}{(cn - ck + ka + 1)^2} \\
x_{NT}(a) &= \frac{(k\,(a - c) + 1)\, Vn}{(cn - ck + ka + 1)^2}
\end{aligned}
\tag{21}
$$

From x_{NT} we have that if $k \geq \frac{1}{c-a}$, then $n-k$ are driven out of the contest. Bearing in mind that outsiders just drain resources away from firm 0 and its potential licensees, let us assume that this is the case, so that the investment levels in (21) have to be rewritten for the fact that the number of competitors to firm 0 is $k = n$. Hence equilibrium investments are

$$\begin{aligned} x_0^f(a) &= \frac{(1 + k(a-1))\, k}{(1+ka)^2} V \\ x_T^f(a) &= \frac{k}{(1+ka)^2} V \end{aligned}$$

with corresponding expected payoffs:

$$\begin{aligned} \pi_0^f(a) &= V \frac{(k(a-1)+1)^2}{(ka+1)^2} \\ \pi_T^f(a) &= V \frac{k(a-1)+1}{(ka+1)^2} \end{aligned}$$

The aggregate payoff of active firms is then

$$\Pi^f(a) = \pi_0^f(a) + k\pi_T^f(a) = V \frac{k(a-1)+1}{ka+1}$$

which is strictly increasing in a and strictly decreasing in k. The maximum that firm 0 can increase its payoff compared to the outset will be the excess of aggregate payoffs over the k insiders' outside options given by $\frac{V}{(cn+1)^2}$ (from (3)). Then, firm 0 maximizes $\Pi_0^f(a) = \Pi^f(a) - k\frac{V}{(cn+1)^2}$ by choice of k and a. The level of k will be set as low as possible, or a as large as possible. However $a = c$ does not represent a transfer of technology so we consider setting k at the lowest level commensurate with foreclosure: denote this by $k^f(a) = \frac{1}{c-a}$. Inserting $k^f(a)$ into $\Pi^f(a)$ gives

$$\Pi^f(k^f(a)) = \frac{V(c-1)}{c}$$

where $\pi_0^f(k^f(a)) = \frac{V(c-1)^2}{c^2}$ and $\pi_T^f(k^f(a)) = \frac{V(c-1)(c-a)}{c^2}$

Total expected payoff of the insiders $\Pi^f(k^f(a))$ is independent of a. Thus, as long as trades are feasible, welfare is independent of the level of $a \in [1, c)$, i.e. the quality of the transferred rent-seeking technology does not affect total welfare. However, from $\Pi_0^f(a) = \frac{V(c-1)}{c} - k\frac{V}{(cn+1)^2}$ we see that firm 0 prefers to set $a = 1$ since $k^f(a > 1) > k^f(a = 1)$.

Proposition 4 *Firm* 0 *will set* a *as low as possible such that* $a = 1$*, giving* $k = \frac{1}{c-1}$. *The outcome is identical to Proposition 3, and trades will be feasible as long as* $n > n^f$ *is satisfied.*

The dominant firm faces a trade off in its choice of the quality of the rent-seeking technology to transfer to rivals. Better quality means stronger competition from firms that have the new technology, but at the same time it allows foreclosure of more of the rival firms. The latter effect dominates here.

4 Discussion and applications

A contest model is particularly applicable for analyzing competition between rivals when prices cannot be used strategically. Non-price competition can take many forms such as product promotion (pharmaceutical products are a good example here according to Huck et al., 2002), R&D effort, lobbying expenditures and investment in quality. For these examples, the transfer of rent-seeking technology that we have discussed can involve opening marketing channels for competitors, loaning out some R&D staff to rivals, or giving access to parts of a contact network.[5] A similar situation can arise in industries where some firms own infrastructure that is either essential or costly to replicate, and where the owners of such infrastructure may choose to award rival firms access to the infrastructure. In particular, within different types of network industries the question whether an access seeker will be

[5] In the pharmaceutical industry it is common to acquire technology for development, i.e. technology that still requires some R&D input to make a marketable product (see Odagiri, 2003). In the context of our model, a superior firm may transfer its technology, and then recipients must spend resources to refine it.

given access to an essential input has attracted a lot of attention from economists as well as policy-makers.[6]

For all of these applications, our model underscores the fundamental trade-off that is present in deciding whether to license a competitive advantage to rivals in a contest; this action will foreclose some competitors at the expense of making some rivals stronger. Since the contest prize is fixed, foreclosure is a prerequisite for the leading firm to be willing to give up its advantage to others. Indeed, the incentive to foreclose is so strong that the superior firm would want to transfer the best version of its rent-seeking technology to others even if an inferior version is available. This is because making a few other firms as strong as possible also forces out as many other rivals as possible.

Our results have some parallels to non-tournament models in which price or quantity are set strategically. Katz and Shapiro (1985) analyze a three-stage R&D game with two downstream firms, and they show that major innovations will not be licensed, but that minor innovations may be licensed by equally efficient firms. Although our set-up is different to theirs, we obtain a similar result: to achieve a pure strategy Nash equilibrium that involves licensing, the difference between the superior technology and the technology available to the other firms cannot be too large. Gallini (1984) considers the use of licensing in the product market as a strategic device to deter rivals from entering into R&D activity. In the present analysis, the innovation is already realized and we only consider when and whether licensing can occur. Rockett (1990) demonstrates how licensing can be used to choose the competitors ("weak" or "strong"), through changing the rules and conditions of the post-patent entry game. By licensing to weak competitors, the licensor is able to enjoy monopoly rent after the patent expires by crowding the market. Yi (1998) investigates licensing when potential licensees differ in the absorptive capacities, and finds that it is optimal to license exclusively to the strong rival.[7] In our model, all of the competitors of the superior firm are ex ante homogeneous, but ongoing work is looking at the case where rivals can be different in terms of their rent-seeking costs.

[6] One recent example is Ordover and Shaffer (2007) who discuss whether mobile network operators will offer access to their networks to firms without own infrastructure.

[7] See also Yi (1999).

One policy implication of our analysis involves transfer of intellectual property rights. Selective or exclusive licensing is an accepted mode of transferring intellectual property rights between firms as outlined by the US Department of Justice and the Federal Trade Commission in the *Antitrust Guidelines for Licensing Intellectual Property* from 1995.[8] Hence some degree of foreclosure will not be ruled out a priori by law. On the other hand, to the extent that the transferred technology guarantees access to an essential input, competition authorities may adopt a policy of no discrimination. Under the competition laws in the United States and the EU the essential-facilities doctrine may apply towards dominating firms which control a bottleneck, and a dominating firm may be obligated to provide access to rivals at non-discriminatory terms (see e.g. Bergman, 2001). Moreover, in regulated industries like telecommunications, obligations which require that the incumbent provides access at non-discriminatory terms are part of the current regulatory regimes both in the United States and the EU. If such non-discriminatory obligations are present, welfare-enhancing licensing of technology may be precluded.

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[8]See the discussion in Scotchmer (2004), chapter 6.

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