The direction of cost-side innovation and buyout preference reversal

Diomides Mavroyiannis

November 28, 2019

Abstract

Do buyouts distort cost-side innovation? The paper studies the choice of innovation in the presence of buyouts. We present a two firm setting model with an entrant and incumbent where the entrant selects a technology. The choice of technologies is a sequential innovation and a radical one. We find that the ability to buyout affects the direction of innovation towards sequential innovations, that is, there exist cases where if no buyouts can occur, the radical innovation would have been pursued but the option to buyout creates a preference reversal. This effect only exists if the entrant has bargaining power. We show that this holds for both Bertrand and Cournot Competition. Finally we discuss the welfare implications of buyouts in this two technology paradigm and the link to the Coase theorem.

Keywords: Industrial Organization, Incomplete Contracts, Innovation
JEL Codes: L41 L25 L26 L51

0.1 Introduction

Models suggest that the possibility for a larger firm to purchase a smaller firm will incentivize smaller firms to innovate. Since this buyout is voluntary, it can only mean that the entrepreneur in question gains. It is difficult to argue against the proposition that increasing the reward of an activity encourages that activity. However this possibility, does not mean that the entrepreneur is more likely to invest in all projects. Quite the contrary, as the possibility increases the incentive to pursue some projects, it simultaneously decreases the incentive to pursue other projects. This paper explores the concept that entrepreneurs are incentivized to pursue projects which are correlated to existing firms activities. Empirical evidence for the link between innovation and the ability to buyout is tenuous because of the difficulty in controlling for causality. There is an empirical correlation which is that industries with higher measures of innovation tend to have a more buyouts (Haucap et al., 2016). However there is no clear causal mechanism to describe this empirical relationship, as it may also be inferred that as innovation slows down, industry consolidation occurs (Comanor and Scherer, 2013). The naive view of buyouts is simply that buyouts increase the potential payoff from innovation. We need only consider that an entrepreneur is considering the possible payoffs from his investment, ceteris paribus, a probability of being bought-out, can only increase the incentive to innovate. The naive view is correct in that an extra source of payoff can only increase the upside to the entrepreneur. Even if the entrepreneur is considering numerous projects, if at least one of the projects being considered has a higher potential payoff, this can only increase the entrepreneurs incentive to innovate. This basic static logic does not necessarily generalize to long run dynamic situations. [1] Nevertheless the distortive effects of buyouts are not limited to being in the long run. The very option to buyout may incur immediate changes in the behavior of firms. The incentive boost from buyouts may change not only the *absolute* payoffs of projects but also their *relative* payoffs. To see why this may occur, we need only consider *who* is buying out the entrepreneur. An entrepreneur has some project, this project has some value in the marketplace that is known to all. If both the entrepreneur and the firm have the same discount factor without a dynamic framework or more restrictive assumptions it is unclear why a transaction would occur[2]. Why would a firm pay the entrepreneur more than the entrepreneurs project *isolated market value*? We explore two potential reasons why this may be the case. Consider first the case where the project is complementary with the buyers activity if bought by the buyer. The buyers willingness to pay for the project will then be what the project is worth

[1]The dynamic effect is usually interpreted as a change in industry structure in such a way that less projects become profitable in the long run Bessen and Maskin (2009)

[2]barring of course the use of a utility function

individually and the complementary revenue that it brings in. This would shift the incentives of the entrepreneur towards projects that are complementary with existing technology. Now consider the case where the entrepreneur's technology is substitutable with the buyers technology. Here the buyers willingness to pay is more complex. If the buyer has the option of shutting the project down by buying it then the buyers excess willingness to pay does not depend on the projects value but depends on the buyers revenue loss if the project is not bought[3]. Either of these two cases have the same result, industry convergence. Even if a project would potentially be very profitable, if the damage it cause to an existing firm is significant enough, then there will be an incentive to buy it out and shut it down. The basic equivalence between complementarity and substitution will be shown in the discussion section below. The static effect can be extended to the dynamic case of the model with projects having different time structures. If the different projects of the entrepreneur will both end up with the same technology but with different patterns of arrival this can equally cause firms to pursue projects of different horizons due to the possibility of being bought out. Specifically we show that projects which pass through intermediate stages of efficiency are more threatening to incumbents than projects which can more directly reach their goal. Even a technology with a lower expected value can be preferred due to the chipping away of incumbent profits. The models presented can be interpreted in one of a few different ways. The most straightforward way is simply to say that a firm wishes to buyout another firm and the regulatory authorities either allow this or forbid this transaction. A different way is simply to say that the entrepreneur cannot be bought out because the projects are not purchasable, perhaps they are not patented or the project is simply not visible to the buyer. The paper is structured as follows. In section 0.2 section we will make a few links with the literature, the model is general enough that it can be interpreted within a couple of strands. Section 0.3.1 will present the model and the results, finishing with a brief numerical example. In section 0.4 we apply the framework to Bertrand and Cournot competition. Finally in section 0.5 we discuss some of the results and in 0.4.4 we give a brief argument to show that complementarities and substitutabilities yield the same willingness to pay.

0.2 Link to the literature

The general trend for mergers and aqcuisition is that industry consolidation is occurring (White, 2002). Perhaps a rather radical example is the consolidation of the beer industry where from 1950 to 2000, the top four firms in the United States went from producing 22%

[3]Assuming the projects market value is lower than the current activity of the buyer, if the project is worth more than the current activity then the buyer will not pay more than other buyers

to producing 95%. The empirical corrolations are numerous, for instance firms that are less innovative are often more likely to engage in buyouts. The work of Gerpott (1995) finds that for innovation to be well absorbed by the acquirer, the firms size must not differ excessively, or said otherwise, the closer the firms are in size, the more likely they are to merge successfully. Higgins and Rodriguez (2006) find that in the pharmaceutical industry, unproductive firms are more likely to engage in acquisition strategies. This is also supported by cross industry studies such as Zhao (2009). There is also empirical work showing that companies with larger patent portfolios and low research expenditure are more likely to acquire(Bena and Li, 2014). The basic theoretic framework used in this paper borrows from Cabral (2003), whose model involves two firms competing in $R\&D$. Each firm has the option of choosng a high variance strategy or a low variance strategy. The general result of the model is that when a firm is lagging behind, it prefers to a high variance strategy, and when it is ahead it chooses a low variance strategy. Our results borrow from this markov chain setup but pursues different questions. Instead of the incentive for projects occurring due to positioning in the market, it occurs due to the market structure itself. That is, the ability to merge distorts which projects are undertaken. Our subject matter is similar to the literature on firms innovating so that they can escape competition effects(Aghion et al. (2005),Aghion et al. (2001),Aghion et al. (1997)). Gilbert et al. (2016) shows these results only hold in duopolies and not oligopolies. Other work includes Phillips and Zhdanov (2013), where it is argued that large firms avoid engaging in $R\&D$ races. However these studies do not include different kinds of innovations, only the relative pressure to innovate depending on market positioning. The paper can be linked to various strands of literature, we give a brief idea of how it relates. The idea can be framed as being an application of the Coase theorem to industry structure. The question of an incumbent being harmed by an entrant can be framed within the externality framework. When transaction costs are low enough, the Coase theorem allows a role for extortion: A may do some activity that he would have no interest in doing because B will be willing to pay for A to stop(Kuechle and Rios, 2012). It is also possible to interpret the results in a mechanism design framework. More specifically, auctions with allocative externalities. This literature is about preferences of ownership where agents have different utilities depending on who among the other agents owns the good, though no utility function is employed here, the results apply to other contexts for a survey of such models see Jehiel and Moldovanu (2005). Finally the model can be framed as being within an incomplete contract framework since there is a question of an inability for the firms to contract ex-ante. Though this is only one possible interpretation of the model, the usual reasons for uncontractibility apply(Hart and Moore, 1999).

0.3 Setup

0.3.1 The dynamic model

The model is made up of an incumbent and an entrant with asymmetric initial positions. The incumbent has three possible payoffs and the entrant has two. The incumbent and entrant start out with initial technologies described by the costs, c_i and c_e, respectively. We assume that the incumbent will initially earn the profit $\pi_i(c_i, c_e)$. The entrant earns no profit with the initial technology, $\pi_e(c_i, c_e) = 0$. We say that $c_e > c_i$ to denote the efficiency of production. The second kind of payoffs in the model are the payoffs once the entrant catches up to the incumbent. The cost associated with this level of development is c_1. This cost is between the other two, $c_i < c_1 < c_e$. The payoff of the incumbent when competing against this cost is lower than the payoff when competing with the less efficient entrant, $\pi_i(c_i, c_e) > \pi_i(c_i, c_{e1})$. If the incumbent were to acquire this intermediate technology, it would not use it since it is less efficient than c_i so the payoff would remain unchanged. If the entrant owns the intermediate technology, the associated payoff would be weakly higher than zero, $\pi_e(c_i, c_{e1}) \geq 0$. Finally the third kind of payoff is the payoff with the advanced technology, c_2. This technology is the most advanced technology available, $c_2 < c_i < c_1 < c_e$. Both firms would benefit from owning this technology and it represents their highest respective payoffs. The entrant in the model must choose what kind of innovation to engage in. Both innovations have the same fixed cost, F. The innovation is the path to the technologies above which can be achieved. There are two options, the first option passes through both stages of efficiency, we call it the *sequential innovation*. The second jumps directly to the second stage of efficiency, we call it the *radical innovation*. Without loss of generality[4] we say that the sequential innovation has no risk associated with it and does not necessarily yield profits from the first stage of efficiency. The sequential option will achieve the intermediate technology, c_1 after t_1 periods and will achieve the advanced technology, c_2 after t_2 periods. The game ends immediately at time T. So if $T - 1 = t_2$ then there will only be one period where the advanced technology payoffs will be achieved. In the application to Bertrand and Cournot we will be assuming that $T - 1 = t_2 = 2$ and $t_1 = 1$ for simplicity. The radical innovation on the other hand will with some probability, q, give the entrant access to the advanced technology directly. So in each time period, with probability q, the firm will have cost c_2. If the technology fails to realize, which occurs with probability $(1-q)$ the entrant will remain at the initial technology c_e. If the radical innovation succeeds at any point, then the entrant will receive the advanced

[4] All results also hold with a sequential innovation that has a weakly lower probability of going to the advanced technology in one go than the radical innovation

technology payoff until T. The difference to notice between these two methods is that the sequential innovation cannot reach the advanced payoff instantly, while the radical one can. These technologies can also be interpreted as high variance and low variance. Adoption cost of the innovations is assumed to be identical. The choice of the radical innovation and sequential technology will be represented by r and s, respectively. It is known that in most standard competitive frameworks, firms will want to merge because merger profits are higher than the sum of profits. So if bargaining is possible and credible through contracting there always exists a positive Nash surplus that can be shared. In our framework this takes the following form:

Assumption 1. *Sub-additive competitive profits*

$$\pi_i(c_{i2}, c_e) \geq \pi_i(c_i, c_{e2}) + \pi_e(c_i, c_{e2})$$

$$\pi_i(c_i, c_e) \geq \pi_i(c_i, c_{e1}) + \pi_e(c_i, c_{e1})$$

We also make clear the assumptions about technology and competition we stated above. The incumbent payoff with the the advanced technology yields higher payoff than with the low technology, $\pi_i(c_{i2}, c_e) > \pi_i(c_i, c_e)$. The default payoff of the incumbent yields higher payment than when the entrant has intermediate technology $\pi_i(c_i, c_e)\pi_i(c_i, c_{e1})$. Finally, the lowest payoff of the incumbent is when the entrant has the advanced technology $\pi_i(c_i, c_e) > \pi_i(c_i, c_{e2}$.

Assumption 2. *Profits increasing in technology and decreasing in competition*

$$\pi_i(c_{i2}, c_e) > \pi_i(c_i, c_e); \qquad \pi_i(c_i, c_e) > \pi_i(c_i, c_{e1}); \qquad \pi_i(c_i, c_e) > \pi_i(c_i, c_{e2})$$

Or simply:

$$\pi_i(c_{i2}, c_e) > \pi_i(c_i, c_e) > \pi_i(c_i, c_{e1}) > \pi_e(c_i, c_{e2})$$

We can re-arrange this assumption to get the following corollary:

Corollary 1. *Assumption 2 implies that* $\Rightarrow \pi_i(c_{i2}, c_e) + \pi_i(c_i, c_{e1}) > \pi_i(c_i, c_e) + \pi_i(c_i, c_{e2})$

We also make an additional assumption that is sufficient but not neccesary for the results[5]. We assume that what the incumbent can earn with the the advanced technology is not larger than the sum of all other possible profits the incumbent can earn in the three situations.

[5]The neccesary and sufficient condition is: $\pi_i(c_{i2}, c_e) \leq \pi_i(c_i, c_e) + (\pi_i(c_i, c_{e2}) + \pi_e(c_i, c_{e2}) + (\pi_i(c_i, c_{e1}) + \pi_e(c_i, c_{e1}))$

Assumption 3. *Bounded advanced technology profits*

$$\pi_i(c_{i2}, c_e) < \pi_i(c_i, c_e) + \pi_i(c_i, c_{e2}) + \pi_i(c_i, c_{e1})$$

We assume that firms do not have a time preference. Though there is no preference for present profits, the firms will still prefer the earlier payment because there is no risk associated with them, firms naturally will prefer one innovation over the other because of their time structure. We now specify the timing of the model. The first decision that occurs is the innovation decision of the entrant, the choice between sequential or radical innovation. If no buyouts are allowed, then the payoff streams occur. If there are buyouts, then after the choice of innovation occurs, negotiation occurs between the entrant and the incumbent for a buyout, after which the buyout payoff streams are realized. Notice that if it were possible for the buyout to materialize before the choice of innovation(ex-ante) this would result in the innovation with the highest expected payoff to happen. This could come about if the entrant was able to credibly signal to the incumbent that the incumbent is capable of undertaking the investment. An implication of an ex-ante buyout is that the incumbent pays a weakly higher amount for the innovation. It is easiest to see in the case where the entrant chooses an innovation which does not maximize market payoffs. This would be the blackmail case where the firm entrant can use the threat of substitutability to make the incumbent pay for the externalities imposed by the entrant. Note that if the radical innovation is bought, this does not guarantee the realization of the technology.

0.3.2 Sequential

The sequential innovation will give the intermediate technology after t_1 periods and the advanced technology after t_2 periods. Therefore the total profit of the entrant is:

$$\begin{aligned}\Pi_{es} &= \pi_e(c_i, c_{i1})(t_2 - t_1) + \pi_e(c_i, c_{e2})(T - t_2) - F \\ &= \pi_e(c_i, c_{i1}) + \pi_e(c_i, c_{e2})(T - t_2) - F\end{aligned}$$

Where we normalize $t_2 - t_1$ to 1. This normalization can done because only the relative length between $t_2 - t_1$ and $T - t_2$ matters. The payoff of the incumbent is similar except that there is an additional stream of payments for the first t_1 periods before the entrant is competitive enough to compete.

$$\Pi_{is} = \pi_i(c_i, c_e)t_1 + \pi_i(c_i, c_{i1}) + \pi_i(c_i, c_{e2})(T - t_2)$$

The merger profit of the incumbent will ignore the first t_1 periods because the intermediate technology is not an improvement on the initial technology. There is no direct value added to the incumbent payoff from variations in t_1. As we will see t_1 does matter for the effect it has on the bargaining disagreement payoff of the entrant. The merger profit is given by:

$$\Pi_s^m = \pi_i(c_i, c_e)t_2 + \pi_i(c_{i2}, c_e)(T - t_2)$$

From the two payoffs of the entrant we can deduce the willingness to pay for the sequential innovation:

$$WTP = \Pi_s^m - \Pi_{is} = (\pi_i(c_i, c_e) - \pi_i(c_i, c_{i1})) + (\pi_i(c_{i2}, c_e) - \pi_i(c_i, c_{e2}))(T - t_2)$$

We need only subtract the payoff of the entrant from the willingness to pay to have the bargaining surplus, that is the value added from merging:

$$S_s = \pi_i(c_i, c_e) - \pi_i(c_i, c_{i1}) - \pi_e(c_i, c_{i1}) + (\pi_i(c_{i2}, c_e) - \pi_i(c_i, c_{e2} - \pi_e(c_i, c_{e2}))(T - t_2)$$

The surplus will be split based on bargaining power $\omega \in [0, 1]$, where if $\omega = 1$, all the surplus is taken by the entrant and if $\omega = 0$, all surplus is taken by the incumbent. Note that there is no fixed cost in the surplus because it has already been incurred and therefore the entrant cannot use it as a negotiation chip. The bargaining payoff of the entrant is therefore:

$$\begin{aligned}
B_{es}(\omega) &= \Pi_{es} + \omega S_s - F \\
&= \omega(\pi_i(c_i, c_e) - \pi_i(c_i, c_{i1}) + (1 - \omega)\pi_e(c_i, c_{i1})) - F \\
&\quad + (\omega(\pi_i(c_{i2}, c_e) - \pi_i(c_i, c_{e2})) + (1 - \omega)\pi_e(c_i, c_{e2}))(T - t_2) \\
B_{is}(\omega) &= \Pi_{is} + (1 - \omega)S_s \\
&= \pi_i(c_i, c_e)t_1 \\
&\quad + \omega\pi_i(c_i, c_{i1}) + (1 - \omega)(\pi_i(c_i, c_e) - \pi_e(c_i, c_{i1})) \\
&\quad + (\omega\pi_i(c_i, c_{e2}) + (1 - \omega)(\pi_i(c_{i2}, c_e) - \pi_e(c_i, c_{e2})))(T - t_2)
\end{aligned}$$

Notice here is that the absolute value of t_1 plays a role because it represents how many periods the incumbent will be uninterrupted in pursuing the baseline profits. So the time when the intermediate innovation kicks in has no positive effect on the entrant but does increase the bargaining profit of the incumbent.

0.3.3 Radical

In the radical innovation, the probability that the entrant receives $T-1$ flows of advanced technology payoffs is given by q. Similarly the probability of receiving $T-2$ is $q(1-q)$, of $T-3$, $q(1-q)^2$, etc. Therefore the general payoff for the entrant is given by:

$$\begin{aligned}\Pi_{er} &= \pi_e(c_i, c_{e2})q\sum_{i=1}^{T-1}(1-q)^{i-1}(T-i) - F \\ &= \pi_e(c_i, c_{e2})\left(T - \frac{1}{q}\left(1-(1-q)^T\right)\right) - F \\ &= \pi_e(c_i, c_{e2})\left(T-\rho\right) - F\end{aligned}$$

Where we define $\rho \equiv \frac{1}{q}\left(1-(1-q)^T\right)$. Note that if $\lim_{q\to 1}\rho \to \rho = 1$ and $\lim_{q\to 0}\rho \to \rho = T$. So ρ can be interpreted as the expected number of periods the entrant will not receive a payment with the radical innovation. An assumption must be made on ρ for the simple reason that the radical innovation has a higher variance in payoffs, so if it also has a lower mean, it will never be pursued, so it must be that in expectation the number of higher payoffs received with the radical innovation is greater than the higher payoff projects with the sequential innovation, this is simply the following:

Assumption 4. *The expected number of payments of the high stream is higher with the radical innovation ($t_2 > \rho$).*

The incumbent payoff will take a similar form to the entrant but will receive non-zero payoffs regardless of the realization. Or to express this in another way, the expected number of payoffs wit competition is given by $T-1$. This means that we need only subtract the previous expected number of streams from $T-1$ to receive the expected number of streams with the initial technology. This is given below:

$$
\begin{aligned}
\Pi_{ir} =& \pi_i(c_i, c_{e2}) \underbrace{q \sum_{i=1}^{T-1} (1-q)^{i-1}(T-i)}_{\text{Expected number of } \pi_i(c_i, c_{e2})} + \pi_i(c_i, c_e) \underbrace{(T-1-q\sum_{i=1}^{T-1}(1-q)^{T-1-i} i)}_{\text{Expected number of } \pi_i(c_i, c_e)} \\
=& \pi_i(c_i, c_{e2}) q \sum_{i=1}^{T-1} (1-q)^{T-1-i} i + \pi_i(c_i, c_e) \sum_{i=1}^{T-1} (T-1-q\sum_{i=1}^{T-1}(1-q)^{T-1-i} i) \\
=& \pi_i(c_i, c_{e2}) q \sum_{i=1}^{T-1} (1-q)^{i-1}(T-i) + \pi_i(c_i, c_e)(T-1-q\sum_{i=1}^{T-1}(1-q)^{T-1-i} i) \\
=& \pi_i(c_i, c_{e2}) \left(T - \frac{1}{q}\left(1-(1-q)^T\right)\right) + \pi_i(c_i, c_e) \frac{(1-q)}{q}\left(1-(1-q)^{T-1}\right) \\
=& \pi_i(c_i, c_{e2}) (T-\rho) + \pi_i(c_i, c_e)(\rho - 1)
\end{aligned}
$$

So with the buyout, the merger payoff of the incumbent is given by a similar expression, where the only difference is that the technology c_2 is owned by the incumbent instead of the entrant.

$$
\begin{aligned}
\Pi_r^m &= \pi_i(c_{i2}, c_e) \left(T - \frac{1}{q}\left(1-(1-q)^T\right)\right) + \pi_i(c_i, c_e) \frac{(1-q)}{q}\left(1-(1-q)^{T-1}\right) \\
&= \pi_i(c_{i2}, c_e)(T-\rho) + \pi_i(c_i, c_e)(\rho - 1)
\end{aligned}
$$

As before, the corresponding willingness to pay of the incumbent and Nash surplus to be shared are given by:

$$
\begin{aligned}
WTP_r &= (\pi_i(c_{i2}, c_e) - \pi_i(c_i, c_{e2}))(T-\rho) \\
S_r &= (\pi_i(c_{i2}, c_e) - \pi_i(c_i, c_{e2}) - \pi_e(c_i, c_{e2}))(T-\rho)
\end{aligned}
$$

The bargaining payoffs are then:

$$
\begin{aligned}
B_{er}(\omega) &= \Pi_{er} + \omega S_r \\
&= (\omega \pi_i(c_{i2}, c_e) - \omega \pi_i(c_i, c_{e2}) + (1-\omega)\pi_e(c_i, c_{e2}))(T-\rho) \\
B_{ir}(\omega) &= \pi_i(c_i, c_{e2})(T-\rho) + \pi_i(c_i, c_e)(1-\rho) \\
&\quad + (1-\omega)(\pi_i(c_{i2}, c_e) - \pi_i(c_i, c_{e2}) - \pi_e(c_i, c_{e2}))(T-\rho) \\
&= \pi_i(c_i, c_e)(\rho - 1) \\
&\quad + (\omega \pi_i(c_i, c_{e2}) + (1-\omega)(\pi_i(c_{i2}, c_e) - \pi_e(c_i, c_{e2})))(T-\rho)
\end{aligned}
$$

The entrant will choose the radical innovation over the sequential innovation based purely on the expected values of the entrants payoffs.

Definition 1. *Let $\Delta\Pi$ denote the incentive to choose the radical innovation when there no buyouts. Specifically, if $\Delta\Pi > 0$ the radical innovation is pursued, and if $\Delta\Pi < 0$ the sequential innovation.*

Proposition 1. *$\Delta\Pi$ is continous and can take positive and negative values.*

Proof. The general form of the incentive is given by taking the difference between the expected values.

$$\begin{aligned} \Pi_{er} &> \Pi_{es} \\ \pi_e(c_i, c_{e2})\,(T-\rho) - \pi_e(c_i, c_{i1}) - \pi_e(c_i, c_{e2})(T-t_2) &> 0 \\ \Delta\Pi \equiv \pi_e(c_i, c_{e2})\,(t_2-\rho) - \pi_e(c_i, c_{i1}) &> 0 \end{aligned}$$

We can notice that the domain of this function is in $\mathbb{R}$ to see that it is continous and well defined since $\rho < t_2$. We can also verify that it's derivative is well defined and positive:

$$\begin{aligned} \frac{\partial \Delta\Pi}{\partial q} &= \pi_e(c_i, c_{e2}) \left(\frac{1-(1-q)^T - Tq(1-q)^{T-1}}{q^2} \right) \\ &= \pi_e(c_i, c_{e2}) \left(\frac{1-(1-q)^{T-1}((1-q)+Tq)}{q^2} \right) \end{aligned}$$

The term $(1-q)^{T-1}((1-q)-Tq)$ is decreasing in q and at $q=0$ becomes 1.

We can see that $\Delta\Pi$ can take positive and negative values by taking the limit with respect to q:

$\lim_{q\to 1} \Delta\Pi = \pi_e(c_i, c_{e2})t_2 - \pi_e(c_i, c_{i1})$

This is positive due to the fact that: $t_2 > 1, \text{and}, \pi_e(c_i, c_{e2}) > \pi_e(c_i, c_{i1})$

$\lim_{q\to 0} \Delta\Pi = \pi_e(c_i, c_{e2})(t_2 - T) - \pi_e(c_i, c_{i1})$

To see that this is negative we need only recall that: $t_2 < T$. □

Intuitively, the higher the transition probability of the radical innovation, the more attractive it is to pursue. It can also similarly be seen that $\Delta\Pi$ is increasing linearly in t_2. We now present our first result:

Proposition 2. *$\Delta\Pi$ is decreasing and convex in T.*

Proof.

The first order condition with respect to T is:

$$\frac{\partial \Delta \Pi}{\partial T} = \frac{\pi_e(c_i, c_{e2})}{q}(1-q)^T \log[1-q]$$

The second condition with respect to T is:

$$\frac{\partial \Delta^2 \Pi}{\partial T^2} = \frac{\pi_e(c_i, c_{e2})}{q}(1-q)^T \log[1-q]^2$$

Due to the fact that$(1-q) < 0,$ the first is negative and second is positive

□

This first order effect is that as the time horizon under consideration increases, the incentive to pursue the radical technology is decreased. The second order effect is that the first order effect becomes marginally less important as the time horizon increases. This is because as the time horizon increases, the sequential project has a higher probability of having the extra payment.

Definition 2. *Let ΔB denote the incentive to choose the radical innovation when there are buyouts. Specifically, if $\Delta B > 0$ the radical innovation is pursued, and if $\Delta B < 0$ the sequential innovation.*

Proposition 3. *ΔB can take on positive and negative values and is continuous.*

Proof.

$$\begin{aligned}
B_{er}(\omega) - F > B_{es}(\omega) - F \\
\leftrightarrow \\
(\omega\pi_i(c_{i2}, c_e) - \omega\pi_i(c_i, c_{e2}) + (1-\omega)\pi_e(c_i, c_{e2}))\,(T-\rho) > \\
\omega(\pi_i(c_i, c_e) - \pi_i(c_i, c_{i1})) + (1-\omega)\pi_e(c_i, c_{i1}) \\
+(\omega(\pi_i(c_{i2}, c_e) - \pi_i(c_i, c_{e2})) + (1-\omega)\pi_e(c_i, c_{e2}))(T - t_2) \\
\leftrightarrow \\
(\omega(\pi_i(c_{i2}, c_e) - \pi_i(c_i, c_{e2})) + (1-\omega)\pi_e(c_i, c_{e2}))\,(t_2 - \rho) \\
-\omega(\pi_i(c_i, c_e) - \pi_i(c_i, c_{i1})) + (1-\omega)\pi_e(c_i, c_{i1}) \equiv \Delta B > 0
\end{aligned}$$

We can see that ΔB can take positive and negative values by taking the limit with respect to q:

$$\lim_{q\to 1}\Delta B = (\omega(\pi_i(c_{i2},c_e)-\pi_i(c_i,c_{e2}))+(1-\omega)\pi_e(c_i,c_{e2}))\,t_2-\omega(\pi_i(c_i,c_e)-\pi_i(c_i,c_{i1}))+(1-\omega)\pi_e(c_i,c_{i1})$$

$$=\omega(t_2(\pi_i(c_{i2},c_e)-\pi_i(c_i,c_{e2}))+\pi_i(c_i,c_{i1})-\pi_i(c_i,c_e))+(1-\omega)(t_2\pi_e(c_i,c_{e2})+\pi_e(c_i,c_{i1}))$$

The first term is positive due to corollary 1 and $t_2>1,$ and the second term is also positive.

$$\lim_{q\to 0}\Delta B = (\omega(\pi_i(c_{i2},c_e)-\pi_i(c_i,c_{e2}))+(1-\omega)\pi_e(c_i,c_{e2}))\,(t_2-T)$$

$$-\,\omega(\pi_i(c_i,c_e)-\pi_i(c_i,c_{i1}))+(1-\omega)\pi_e(c_i,c_{i1})$$

$$=\omega((t_2-T)(\pi_i(c_{i2},c_e)-\pi_i(c_i,c_{e2}))+\pi_i(c_i,c_{i1})-\pi_i(c_i,c_e))+(1-\omega)((t_2-T)\pi_e(c_i,c_{e2})+\pi_e(c_i,c_{i1}))$$

The ω term is negative due to the fact that $T-t_2\geq 1$ and corollary 1

For the $1-\omega$ term we can see that it is negative due to $T-t_2\geq 1$ and $\pi_e(c_i,c_{e2})>\pi_e(c_i,c_{i1}))$

We can also see that the derivative of this function with respect to q is well defined and positive:

$$\frac{\partial\Delta B}{\partial q}=(\omega(\pi_i(c_{i2},c_e)-\pi_i(c_i,c_{e2}))+(1-\omega)\pi_e(c_i,c_{e2}))\left(\frac{1-(1-q)^{T-1}((1-q)+Tq)}{q^2}\right)$$

Where $\pi_i(c_{i2},c_e)-\pi_i(c_i,c_{e2})$ is positive by definition and the larger parenthesis is weakly positive by the same reasoning as in proposition 1. □

Proposition 4. *If the entrant has bargaining power* ($\omega>0$)*, a switch from the no-buyout to the buyout regimes, weakly increases the incentive for the entrant to pursue the sequential innovation* ($\Delta B<\Delta\Pi$)

Proof. We need that $\omega>0$ since if $\omega=0$, $\Delta B=\Delta\Pi$. We define: $\chi\equiv\Delta B-\Delta\Pi$. So if $\chi<0$ this implies that the radical innovation is pursued less in the buyout regime and the $\chi>0$ implies the inverse. If we set $\Delta B\leq\Delta\Pi$.

$$\omega\left(\pi_i(c_{i2},c_e)-\pi_i(c_i,c_{e2})-\pi_e(c_i,c_{e2})\,(t_2-\rho)\right.$$
$$\left.-\,\pi_i(c_i,c_e)-\pi_i(c_i,c_{e1})-\pi_e(c_i,c_{e1})\right)=\chi\leq 0$$

Note that $\chi\leq 0$ is the necessary and sufficient condition for the sequential innovation to be over pursued relative to the radical innovation. We now show that, assumption 2 is also a sufficient condition. First note that the sign of χ is the sign of $\frac{\chi}{\omega}$. We can write $\frac{\chi}{\omega}$ in the following way:

$$\pi_i(c_{i2},c_e)-\pi_i(c_i,c_e)\leq\pi_e(c_i,c_{e2})\,(t_2-\rho)+\pi_i(c_i,c_{e2})+\pi_i(c_i,c_{e1})+\pi_e(c_i,c_{e1})$$

We can note that by assumption 4, $(t_2-\rho)$ is positive and since all the entrant profits are strictly positive. If we start from assumption 3

$$\pi_i(c_{i2}, c_e) \leq +\pi_i(c_i, c_e) + \pi_i(c_i, c_{e2}) + \pi_i(c_i, c_{e1})$$

We can see that the condition is verified.

□

As seen in the proposition, the bargaining power plays an important role for the distortion. At the extreme we have the following corollary.

Corollary 2. *If the entrant has no bargaining power, the buyout is not distortive.*

0.3.4 The willingness to lobby for buyouts

The buyout option will always benefit the entrant because by definition the entrant can always just ignore that option. However the buyout option does not always benefit the incumbent. It is worth considering how the willingness to pay of the incumbent for a policy change varies with parameters. Let $\Pi = max\{\Pi_{es}, \Pi_{er}\}$ and $B = max\{B_{es}, B_{er}\}$. If a change in the legality of buyouts does not affect the incentives of the entrant, $F > B > \Pi$ then there is no willingness to pay. The incumbent will have to balance out the risks of competition and blackmail with the possible synergies that could be present with the buyout.

Case 1: Buyouts affect decision to enter:

Suppose first that the possibility for a buyout affects the decision to enter. This corresponds to the fixed cost is larger than the non-merger choice but is smaller than the merger choice, $B > F > \Pi$.

Proposition 5. *If the buyout can effect the entry decision, there always exists a negotiating power,$\overline{\omega}$ where if $\omega > \overline{\omega}$, the incumbent will have a willingness to pay to prevent mergers, and if $\omega < \overline{\omega}$, the entrant will have a willingness to pay to legalize mergers.*

Proof. In this case the corresponding willingness to pay for policy change is given by:

$$
\begin{aligned}
&B_{is}(\omega) > (T-1)\pi_i(c_i, c_e) \\
&\qquad \leftrightarrow (\omega\pi_i(c_i, c_{i1}) + (1-\omega)(\pi_i(c_i, c_e) - \pi_e(c_i, c_{i1}))) \\
&\qquad + (\omega\pi_i(c_i, c_{e2}) + (1-\omega)(\pi_i(c_{i2}, c_e) - \pi_e(c_i, c_{e2})))(T - t_2) \\
&\qquad - \pi(c_i, c_e)(T - 1 - t_1) > 0 \\
&\quad \text{If } \omega = 0 : \pi_i(c_i, c_e) - \pi_e(c_i, c_{i1}) + (\pi_i(c_{i2}, c_e) - \pi_e(c_i, c_{e2}))(T - t_2) - \pi(c_i, c_e)(T - 1 - t_1) > 0 \\
&\quad \text{If } \omega = 1 : \pi_i(c_i, c_{i1}) + \pi_i(c_i, c_{e2})(T - t_2) - \pi(c_i, c_e)(T - 1 - t_1) > 0
\end{aligned}
$$

Notice that this expression can be negative. Depending on how large $\pi(c_i, c_e)$ is relative to the rest of the expression. This expression can be used to determine how much bargaining power the incumbent would need in order to have a zero willingness to pay.

It is also possible that the option to buyout affects is affects the option to enter but not the project undertaken. If the project that would have been undertaken was the sequential one then the willingness to pay would be the same as above. If on the other hand the entrant enters and pursues the radical innovation then the willingness to pay of the incumbent is:

$$
\begin{aligned}
&B_{ir}(\omega) > (T-1)\pi_i(c_i, c_e) \\
&\qquad \leftrightarrow (\omega\pi_i(c_i, c_{e2}) + (1-\omega)(\pi_i(c_{i2}, c_e) - \pi_e(c_i, c_{e2})) - \pi_i(c_i, c_e)) \left(T - \frac{1}{q}\left(1 - (1-q)^T\right)\right) > 0 \\
&\quad \text{If } \omega = 0 : (\pi_i(c_{i2}, c_e) - \pi_e(c_i, c_{e2}) - \pi_i(c_i, c_e)) \left(T - \frac{1}{q}\left(1 - (1-q)^T\right)\right) \\
&\quad \text{If } \omega = 1 : (\pi_i(c_i, c_{e2}) - \pi_i(c_i, c_e)) \left(T - \frac{1}{q}\left(1 - (1-q)^T\right)\right)
\end{aligned}
$$

The case where $\omega = 0$, where the incumbent has all the negotiating power, is strictly positive due to assumption 1. The case where all the negotiating power is given to the entrant, $\omega = 1$, results on the other hand is negative due to the competitive effect. □

Case 2: Buyouts only affect the preference

This leaves us with one case, the case where the firm would have entered anyway but the buyouts cause it to pursue the the sequential innovation. An intuitive scenario in which this case would occur is if the radical innovation is very effective, this would entail a large risk to the incumbent, which would create a high willingness to pay to avoid the potential losses.

Due to proposition 4, we know that we only need to consider the case where the buyout shifts incentives to the sequential technology. In this case the willingness to pay would be given by the following expression:

Proposition 6. *If buyouts do not affect entry decision, the willingness to pay for buyouts by the incumbent is always positive.*

Proof.

$$
\begin{aligned}
&B_{is}(\omega) > \Pi_{ir} \\
&\leftrightarrow \pi_i(c_i,c_e)t_1 + \omega\pi_i(c_i,c_{i1}) + (1-\omega)(\pi_i(c_i,c_e) - \pi_e(c_i,c_{i1})) \\
&+ (\omega\pi_i(c_i,c_{e2}) + (1-\omega)(\pi_i(c_{i2},c_e) - \pi_e(c_i,c_{e2})))(T-t_2) \\
&> \pi_i(c_i,c_{e2})\left(T-1-\frac{1}{q}\left(1-(1-q)^{T-1}\right)\right) + \pi_i(c_i,c_e)\frac{(1-q)}{q}\left(1-(1-q)^{T-1}\right) \\
\leftrightarrow&\pi_i(c_i,c_e)(t_2-\omega-\frac{1}{q}\left(1-q-(1-q)^T\right)) + (\omega\pi_i(c_i,c_{i1}) - (1-\omega)\pi_e(c_i,c_{i1})) \\
&+ (1-\omega)(\pi_i(c_{i2},c_e) - \pi_e(c_i,c_{e2}))(T-t_2) \\
&+ \pi_i(c_i,c_{e2})\left(\omega(T-t_2) - T + \frac{1}{q}\left(1-(1-q)^T\right)\right) > 0 \\
\text{If } \omega = 0 :& \; \pi_i(c_i,c_e)(t_2-\frac{1}{q}\left(1-q-(1-q)^T\right)) - \pi_e(c_i,c_{i1}) \\
&+ (\pi_i(c_{i2},c_e) - \pi_e(c_i,c_{e2}))(T-t_2) + \pi_i(c_i,c_{e2})\left(-T+\frac{1}{q}\left(1-(1-q)^T\right)\right) > 0 \\
\text{If } \omega = 1 :& \; \pi_i(c_i,c_e)(t_2-\frac{1}{q}\left(1-(1-q)^T\right)) + \pi_i(c_i,c_{i1}) \\
&- \pi_i(c_i,c_{e2})\left(t_2-\frac{1}{q}\left(1-(1-q)^T\right)\right) > 0
\end{aligned}
$$

Some deduction is possible from the last term, with $\omega = 1$, when the the incumbent has none of the negotiating power. Since we know that the profits of the incumbent are higher when the entrant is less competitive, $\pi_i(c_i,c_e) > \pi_i(c_i,c_{e2})$, the willingness to pay is always positive. □

0.4 Applications:

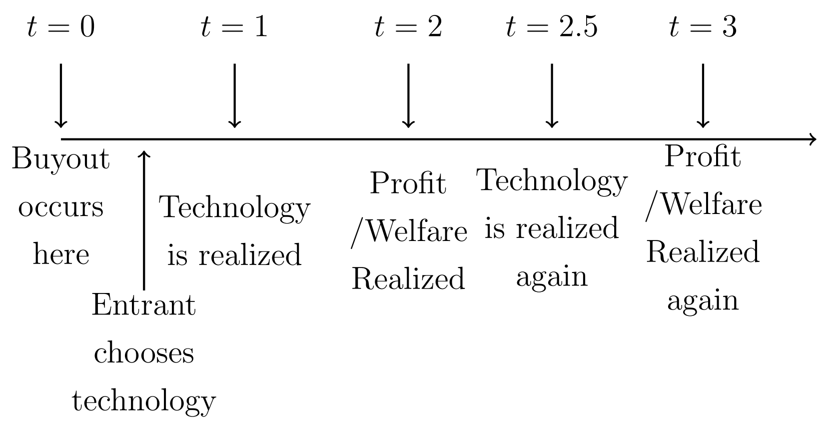
To clarify ideas and develop our intuition we now apply the general concept to Bertrand and Cournot competition. Without loss of generality we assume that both $\pi_i(c_i,c_e)$ and $\pi_i(c_{i2},c_e)$ are monopoly profits. That is, the gap between the technologies is sufficiently large that the entrant sets the monopoly price. We also assume a linear demand function of the form $D(x) = 1 - x$ and linear cost structure. As such the monopoly payoffs are:

$$\pi_i(c_i, c_e) = \left(\frac{1 - c_i}{2}\right)^2; \quad \pi_i(c_{i2}, c_e) = \left(\frac{1 - c_{i2}}{2}\right)^2;$$

Note that the implicit assumption here is that $\frac{1+c_i}{2} < c_e$, due to the fact that the monopoly price must be lower than the cost of production of the competitor. Finally we assume that the game lasts two periods and that the sequential innovation gives the intermediate technology in period 1 and the advanced technology in period 2. That is, the entrant will earn one stream of low technology and one stream of high technology, $T - 1 = t_2 = 2$ and $t_1 = 1$.

0.4.1 Ex-ante buyout

As a baseline scenario we first briefly take a look at what occurs if the buyout is ex-ante. That is, the buyouts occurs before the entrant chooses his technology.



The analysis in this case is straightforward, we need only calculate the difference in profits in the case with the radical innovation and the sequential innovation.

Proposition 7. *If the buyouts are ex-ante, the decision criteria for the radical innovation to be chosen by the incumbent is:*

$$\frac{3 - \sqrt{5}}{2} < q^*$$

Proof. We need only set

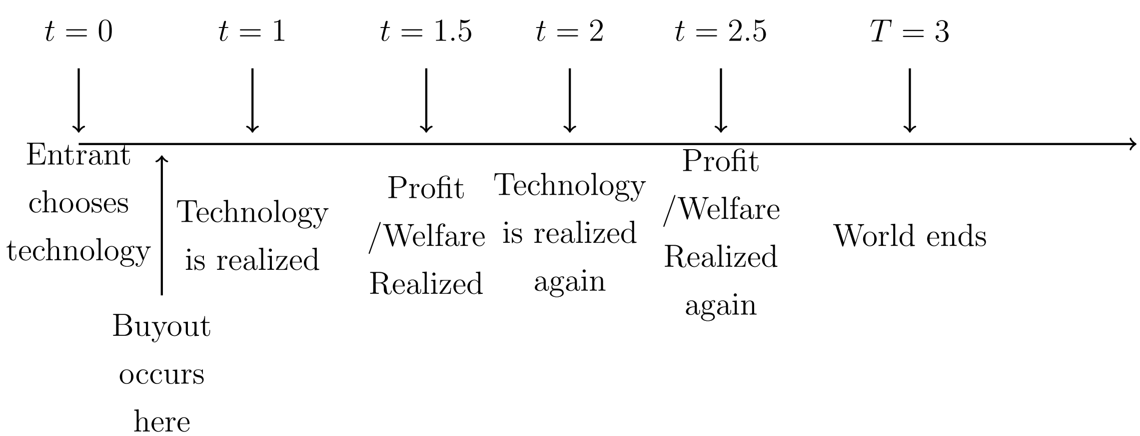
$$\Pi_r^m > \Pi_s^m$$
$$\pi_i(c_i, c_e)(1-q)(2-q) + \pi_i(c_{i2}, c_e)q(3-q) > \pi_i(c_i, c_e) + \pi_i(c_{i2}, c_e)$$

□

This is intuitive because, if the radical innovation has a high enough probability of being achieved, the incumbent will opt for it. Note that the ex-ante case is identical for both Cournot and Bertrand competition. If there is a reputational mechanism at work or perhaps a working relationship that already exists between the entrant and the incumbent then the ex-ante case becomes more plausible. Signaling mechanisms may also exist that enable the ex-ante buyout to occur. For instance if there is some way for the entrant to communicate why they can undertake a specific invention then this will also suffice.

0.4.2 Ex-post Bertrand

The ex-post case is the setup we used in the more general case. Apart from the incomplete contract justifications, it could occur because there are too many firms innovating and the incumbent cannot tell who has innovative capabilities before they invest. Bertrand competition reduces the distortion effect to a simpler form, this is because in Bertrand competition only the highest technology firm makes profits. Additionally we know that the payoffs, when not the monopoly payoff, will be that the most advanced firm will price at the production cost of the second most advanced firm. Therefore $\pi_i(c_i, c_{e1}) = (1-c_{e1})(c_{e1}-c_i)$ and $\pi_e(c_i, c_{e2}) = (1-c_i)(c_i-c_{e2})$



If the buyout is not possible the bargaining payoffs are not available for either firm. Under such conditions the entrant will compare the direct market payoffs of the innovation.

Proposition 8. *If no buyouts can occur, the entrants preferences for the radical innovation are identical to the incumbent when the buyout is ex-ante.*

Proof.

$$\Pi_{er} > \Pi_{es}$$
$$q\pi_e(c_i, c_{e2})(3-q) > \pi_e(c_i, c_{e2})$$
$$\pi_e(c_i, c_{e2})(q(3-q)-1) > 0$$

$$q > \frac{3-\sqrt{5}}{2} = q^b$$

Notice that, $q^b = q^*$, therefore the preferences are identical. □

In other words, no distortion effect occurs if there are no buyouts. The result is not necessarily intuitive because the profits being compared are not of the same type. That is, the incumbents profits are monopoly profits whilst the entrants profits are competitive. Nevertheless since the absolute value of the gain does not play a role but only the relative gain does, this drives the result. We now proceed to compare the choice between the radical and sequential innovation when buyouts are allowed.

Proposition 9. *If buyouts are possible, then the q required for the radical innovation to be pursued will be higher than $q^b = q^*$.*

Proof. If buyouts are allowed, the radical innovation will be pursued if:

$$B_{er}(\omega) > B_{es}(\omega)$$
$$\rightarrow q\pi_e(c_i, c_{e2})(3-q)(1-\omega) + \omega q\pi_i(c_{i2}, c_e)(3-q)$$
$$> \pi_e(c_i, c_{e2})(1-\omega) + \omega(\pi_i(c_i, c_e) + \pi_i(c_{i2}, c_e) - \pi_i(c_i, c_{e1}))$$
$$\leftrightarrow \pi_e(c_i, c_{e2})(q(3-q)-1)(1-\omega) + \omega\pi_i(c_{i2}, c_e)(q(3-q)-1) - \omega(\pi_i(c_i, c_e) - \pi_i(c_i, c_{e1})) > 0$$

Note that the third term is negative because $\pi_i(c_i, c_e)$ is a monopoly profit whilst $\pi_i(c_{i2}, c_e)$ is a competitive profit. This implies that unlike before for the inequality to be satisfied, q must not only be large enough to make the expressions it interacts with positive but it must also be large enough to overcome the third term. □

Note that this is just a special case of proposition 4. But it serves to illustrate how the expression simplifies due to the Bertrand assumptions. Bertrand competition the preference shift is entirely due to the difference in profit of the incumbent between the default profit and the profit against an entrant with intermediate cost, in other words the externality, $\omega(\pi_i(c_i, c_e) - \pi_i(c_i, c_{e1}))$. The fact that the entrant can bargain on the externality is is the driving factor behind this result.

When does the buyout option help the incumbent?

We now return to the case where we consider the point of view of the incumbent. By looking at the preferences of the incumbent we can also derive a willingness to lobby. That is, if the incumbent loses from the ability to buyout because the competitive effect is larger than the potential technology boost. It is trivial to note that the incumbent does not have a willingness to lobby if the option to buyout does not change the preferences of the entrant. The incumbent will prefer to the buyouts to exist as a function of his own bargaining power, $1 - \omega$. We again look at the special case of the Bertrand competition with parameters $T - 1 = t_2 = t_1 + 1 = 2$. In what corresponds to case 0.3.4 in the general section, the conditions collapses to the following.

$$
\begin{aligned}
B_{is}(\omega) &> 2\pi_i(c_i, c_e) \\
&\leftrightarrow -\omega(\pi_i(c_i, c_e) - \pi_i(c_i, c_{i1})) + (1-\omega)(\pi_i(c_{i2}, c_e) - \pi_e(c_i, c_{e2})) > 0 \\
1 - \omega &> \frac{\pi_i(c_i, c_e) - \pi_i(c_i, c_{i1})}{\pi_i(c_i, c_e) - \pi_i(c_i, c_{i1}) + \pi_i(c_{i2}, c_e) - \pi_e(c_i, c_{e2})} \\
B_{ir}(\omega) &> 2\pi_i(c_i, c_e) \\
&\leftrightarrow ((1-\omega)(\pi_i(c_{i2}, c_e) - \pi_e(c_i, c_{e2})) - \pi_i(c_i, c_e))q(3-q) > 0 \\
1 - \omega &> \frac{\pi_i(c_i, c_e)}{\pi_i(c_{i2}, c_e) - \pi_i(c_i, c_{e2})}
\end{aligned}
$$

The first result is the outcome if the buyout incentivizes the entrant to innovate with the sequential technology when the entrant would have otherwise not innovated at all. The bargaining power must be greater than the ratio of the profit loss from the externality,$\pi_i(c_i, c_e) - \pi_i(c_i, c_{i1})$ to the profit loss from the externality and the difference in profit from what the incumbent can achieve with the best technology and what the entrant can achieve with the best technology,$\pi_i(c_{i2}, c_e) - \pi_e(c_i, c_{e2})$.

Similarly with the radical innovation it must just be that the bargaining power of the incumbent is greater than the ratio of the default profit to the difference in profit from what the incumbent can achieve with the best technology and what the entrant can achieve with the best technology. Notice that this means that in the radical case, the willingness to lobby for buyouts is independent of the efficiency of the technology, q. This is because q is equally harmful as it is helpful, a high q increases the probability of achieving the high result but it also increases the negotiating power of the entrant by an equal amount.

Finally we have the case where the entrant would have entered anyway but will instead pursue the sequential innovation. Since the entrant would have entered anyway but the only thing that has changed is the choice of innovation this is the difference in payoff between bargaining for the sequential technology and competing with the radical technology.

$$
\begin{aligned}
&B_{is}(\omega) > \Pi_{ir} \\
\leftrightarrow &\pi_i(c_i, c_e)(q(3-q) - \omega) + \omega\pi_i(c_i, c_{i1}) + (1-\omega)(\pi_i(c_{i2}, c_e) - \pi_e(c_i, c_{e2})) > 0 \\
\leftrightarrow &(1-\omega) > \frac{\pi_i(c_i, c_e)(1 - q(3-q)) - \pi_i(c_i, c_{i1})}{\pi_i(c_i, c_e) - \pi_i(c_i, c_{i1}) + \pi_i(c_{i2}, c_e) - \pi_e(c_i, c_{e2})}
\end{aligned}
$$

Notice here that q does enter into the equation. The higher q is the higher is the willingness to lobby and the lower the required barganing power for the incumbent to wish to lobby.

0.4.3 Ex-Post Cournot

We will not detail the calculations the Cournot, our main purpose for this section is to show that the distortion of buyouts in Cournot is lower than in Bertrand. The payoffs of the entrant and incumbent in Cournot, with the same demand function as before, $D(q) = 1 - q$ are given by:

$$
\pi_e(c_i, c_{e1}) = \left(\frac{1 - 2c_{e1} + c_i}{3}\right)^2 ; \pi_e(c_i, c_{e2}) = \left(\frac{1 - 2c_{e2} + c_i}{3}\right)^2 ;
$$
$$
\pi_i(c_i, c_{e1}) = \left(\frac{1 + c_{i1} - 2c_i}{3}\right)^2 ; \pi_i(c_i, c_{e2}) = \left(\frac{1 + c_{i2} - 2c_i}{3}\right)^2
$$

If $c_i - c_{e1} = c_{e2} - c_i$ this would would imply the simplification that $\pi_e(c_i, c_{e1}) = \pi_i(c_i, c_{i2})$ and $\pi_e(c_i, c_{e2}) = \pi_i(c_i, c_{i1})$, this entailment would also hold in the case of Bertrand competition,

$\pi^c_{e2} = \pi^c_{i2}$ and $\pi^c_{e1} = \pi^c_{i1}$. As before we assume the initial profit is a monopoly profit. The first result is that the sequential innovation is pursued more often in than in Bertrand.

Proposition 10. *Without buyouts, if the radical innovation is preferred in Cournot competition, it is also preferred in Bertrand.*

Proof.

$$\begin{aligned} \Pi_{er} &> \Pi_{es} \\ q\pi_e(c_i, c_{e2})(3-q) &> \pi_e(c_i, c_{e1}) + \pi_e(c_i, c_{e2}) \\ q &> \frac{3}{2} - \frac{\sqrt{5\pi_e(c_i, c_{e2}) - 4\pi_e(c_i, c_{e1})}}{2\sqrt{\pi_e(c_i, c_{e2})}} = q^c \end{aligned}$$

We need only see that $q^c > q^b$. To do so we can notice that $\frac{\partial q^c}{\partial \pi_e(c_i, c_{e1})}$ is positive and that if $\pi_e(c_i, c_{e1}) = 0$, we are left with q^b $\square$

The intuition behind this result is due to the lower advantage of being the market leader. In Cournot the entrant earns a profit even with the intermediate technology which makes the lag time between the intermediate stage and the advanced stage less important. This means the entrant requires a higher q to be convinced to pursue the radical innovation.

Proposition 11. *If the payoff of the incumbent when the entrant has the advanced technology is the same in both Bertrand and Cournot competition, the cutoff point for the radical innovation to be pursued with buyout is lower than in Bertrand.*

Proof.

$$\begin{aligned} \Pi_{er} + \omega NS_r &> \Pi_{es} + \omega NS_s \\ (q(3-q)-1)((1-\omega)\pi_e(c_i, c_{e2}) + \omega((\pi_i(c_{i2}, c_e) - \pi_i(c_i, c_{e1})))) \\ +(1-\omega)\pi_e(c_i, c_{e1}) - \omega(\pi_i(c_i, c_e) - \pi_i(c_i, c_{e2})) &> 0 \end{aligned}$$

Note here that this expression is identical to the expression in proposition 9 except for the extra term, $\pi_e(c_i, c_{e1})(1-\omega)$ which is always positive. Note however that this not entail the cuttoff point is always higher than in Bertrand, it depends on if gap between $\omega(\pi_i(c_i, c_e) - \pi_i(c_i, c_{e2}))$ is higher than the same gap in Bertrand competition. Note that the monopoly profit,$\pi_i(c_i, c_e)$ is identical in both cases. Therefore if the profit of the incumbent when the entrant has the advanced technology is identical in both Cournot and Bertrand, Cournot has a lower q for it to be pursued due to the extra positive term, $(1-\omega)\pi_e(c_i, c_{e1})$ $\square$

The buyout case has two relevant effects which are in friction. On one hand the same effect as the non-buyout case, namely that being behind is not as important to the entrant. However there is now a second effect which is that the incumbent is less harmed by being overtaken, so there is a lower willingness to buyout. Note that since $q^b < q^c$ without buyout, and $q^b > q^c$ when there is a buyout, this means the difference between the buyout and the non-buyout case is smaller in Cournot than in Bertrand. Which means that the distortion effect is lower overall for the case of Cournot.

0.5 Discussion

The intuition behind result 9 is a consequence of the Coase theorem. The activity of the entrant can be interpreted to have an externality on the incumbent. Both the radical and sequential innovation have such an externality. However the sequential innovation has an externality with no associated direct benefit to the entrant beyond the ability to threaten the incumbent. In other words, if there was no bargaining, the entrant would be indifferent to increasing the damage done to the incumbent, it is a variable which does not enter into the decision criteria. However as soon as there is a buyout, the entrant now can negotiate on the negative externality being pushed on the incumbent. This incites the entrant to pursue the technology that has this externality relatively more than before.

The ability to blackmail has been studied in the context of the Coase theorem(H.Demsetz, 1972). In the rancher and farmer case study, the rancher has her cows graze whilst the farmer grows crops. If we suppose that the rancher does not have to compensate the farmer for the damage done, then the farmer will be willing to pay to stop the rancher. However in such a case, if the rancher has options which are not individually attractive but are very costly to the farmer, she can use these options to extort the farmer into giving a higher payment. It is important that the rancher be able to commit to applying this costly action, otherwise if the farmer can just say no to the offer, it is not credible that the rancher will act in a costly manner.

In fact this is very similar to our story here. When the entrant pursues the radical innovation there is an externality to the choice where it threatens to take away the profits of the incumbent, this is a productive action that can occur in either of the two periods. On the other hand the sequential innovation can be seen as an unproductive action followed by a productive action. This case is to be juxtaposed to a sequential innovation that would have no externality to the incumbent, this would reduce the payoff potential of the entrant if there is a buyout and be less distortionary.

It is interesting that there are different informational requirements in the two cases. In the case of no buyouts the informational pre-requisites on the entrant are simply to know the profit potential of the project, the cost of the project, and the probability of innovating. On the other hand the ability to buyout actually has a higher burden in terms of rationality on the entrant, that is to compute the optimal decision one must know not only the potential payoffs of the project but also the revenue loss of the incumbent and the negotiating power. So while the model made abstractions from information asymmetries, it is quite clear that buyouts have a higher information burden, this could be captured merely by interpreting it as part of the cost.

We include the details of the welfare analysis in the appendix but give some cursory details here. In general since the buyout causes a monopoly this monopoly needs to be an improvement from what would occur otherwise, there are only two cases to consider. One alternative a less efficient monopoly, that is a monopoly with the high cost of production, this case occurs if without the buyout the entrant would not enter. Relative to this less efficient monopoly, the buyout can only improve the situation with a more efficient monopoly. The second alternative could be that the entrant would have pursued the innovation anyway, but the effect of the entrant on the market is less important and the more efficient monopoly gives a higher welfare. However this second case is not achievable in the modes of competition used here.

It is perhaps also interesting to ask which of the projects maximize welfare. The answer is a bit complex, the welfare maximizing choice with buyouts is the same as the profit maximizing choice without buyouts(see appendix). Since we have established that the choice of the firm in the ex-ante case pursue the radical innovation more often, this implies that whenever there is a preference reversal without affecting the decision entry, this reduces welfare. The reason this occurs is because the negative externality in the intermediate period is internalized when there is a buyout. This is consistent with coase as it implies that the efficient option is pursued either when the externality is ignored by entrant or when it is fully internalized due to the buyout.

The model predicts a number of things for industry structure. If the entrant is unknown to the incumbent until the the entrant starts to innovate, this immediately gives rise to distorting effects. This may occur if we have an industry where innovation occurs from many small entrants, the prediction is that the small entrant will over-pursue incremental innovations because it is the best way to make their project profitable. An example of such an industry is the relationship of biotechnological firms to the pharmaceutical industry. That is, numerous small entrants who threaten the incumbent who is already firmly established.

On the other hand if an industry has endogenous mechanisms so that buyouts can occur before irreversible directional investments are undertaken, such as reputational mechanisms, then that industry will have have a higher tendency to pursue radical innovations.

The model presented is specifically about cost side innovations, the strength of the conclusions depends on the ratio of production to development cost. A high production cost is about producing the marginal unit, if this is expensive then a proportional decrease in this cost will have greater effect on competitive pressure. A high development cost implies that the creation of the product has a sunk cost in the beginning which blocks entry, if this is low then industries may more easily enter and hence there will be more interactions of the sort described in this model. A high development cost is important for the buyouts described because such a cost, like all sunk costs, cannot be used for negotiating with the incumbent. Examples of industries with a high production to development cost are established industries where the good is generally larger, for instance cars, trains, airplanes, boats or metalworks are likely to have a high cost of production without there there being a high cost to development. An example of an industry where the model implies the effects will be weaker is an industry such as the information technology sector, this is because software exhibits very high development cost(programming) and a low cost to produce a unit of software.

A rather different method of envisioning a cost side innovation is management changes. Some entrant may have some cutting edge method of managing employees that can either reduce the cost of the firm gradually or it may have some scheme were a large structural change occurs and the costs are reduced quickly. The application of the model in this case is that incumbents will buyouts will lead to the entrant over-pursuing the slow employee cost reduction technique rather than the fast and risky one.

Another natural example of a cost side innovation is energy innovations. Perhaps rather intuitively, firms are more likely to buyout entrepreneurs who can cause damage even with an ineffective technology than firms with much better prospects for advancement but no intermediate stage. In energy this may look like firms buying out solar or wind technologies more than buying out nuclear plans.

0.6 Conclusion

The paper presents a preference reversal within two paradigms. We find that policy levers have ambiguous effects, enabling buyouts can have both a negative and positive effects on welfare and this is not necessarily a function of the willingness to pay. Instead it is a function of substitutability and complementarity. Empirically, the willingness to pay of incumbents for the entrants cannot be used as a proxy for reducing rent seeking since, the willingness to pay can stem equally from substitutability and complementarity.

We present a model which implies that mergers should not only be seen from a point of view of competition vs efficiency but also from the point of view of innovative convergence. When firms can buy other firms this is in essence license for firms to play correlated strategies and there is a strong incentive for firms to choose industries which are already existing without reasons having to do with industry level characteristics. As such anti-trust policy should take into account the effects buyouts on industry convergence. Specifically, for patents, if the role of the patent is to exclude other firms, then the kind of patenting will not be affected, if on the other hand the role of patenting is to be bought over by larger firms, this will favor industry convergence. The basic reasoning implies that either patents requirement should more stringent when an innovation improves on a product with an existing industry or if possible, if entrants represent a larger threat to incumbents, buyouts rules should be more demanding. .

Finally, the model implies that there is a demand for lobbying. If we are in a paradigm where enabling buyouts create a preference reversal for the entrant and where this is not preferred by the incumbent, then this creates a willingness to pay from the incumbent which will disable buyouts.

Apendix 1: Welfare equations

There are four possible consumer surplus outcomes. The two monopoly outcomes, where the incumbent has the default or the highest technology, S_I and S_{I2}, respectively. Or the two competitive outcomes, where the incumbent must set a price when the entrant has an intermediate technology and when the entrant has the highest technology, S_{I1} and S_E respectively.

A reminder that the social surplus is found by computing: $\frac{1}{2}(1-p)(1-p)$. In the case of monopoly the price is simply the monopoly price in a Bertrand context. While if the outcome is competitive, the price is simply the competitors cost. The four possible social outcomes are given below:

$$S(c_i, c_e) = \frac{(1-c_i)^2}{8}; \quad S(c_{i2}, c_e) = \frac{(1-c_{i2})^2}{8}; \quad S(c_i, c_{e1}) = \frac{(1-c_{i1})^2}{2}; \quad S(c_i, c_{e2}) = \frac{(1-c_i)^2}{2}$$

Note that the consumer only prefers the buyouts if it incentives the entrant to pursue the projects. If the projects are already being pursued without the buyout then the consumer can only lose because whilst before there was some possibility of a competitive outcome, now there are only monopoly outcomes possible. From the welfare perspective the bargaining power only matters if it will change the choices of the firms. Otherwise bargaining power will be zero sum, therefore we need only look at the market profits and the social surplus of consumers to compute the welfare function. In the two cases where there is a monopoly this is either the monopoly with the default cost or the monopoly with the lower cost. We recall here that monopoly with the lower price is preferred over the monopoly with the default price for both consumers and the monopolist. These outcomes are given by:

$$\begin{aligned} w(c_i, c_e) &= \frac{(1-c_i)^2}{8} + \frac{(1-c_i)^2}{4} = \frac{3(1-c_i)^2}{8} \\ w(c_{i2}, c_e) &= \frac{3(1-c_{i2})^2}{8} \end{aligned}$$

Similarly the welfare payoffs of both consumers and the firms are given simply by the competitive profits and the consumer surplus. This represents a shift from firms to the consumers. From the consumer point of view it is preferred that the entrant be the market leader because the price will necessarily be lower. However this does not neccesarily mean that the entrant will have less profits than the competitive case where the incumbent is ahead.

$$
\begin{aligned}
w(c_i, c_{e1}) &= \frac{(1-c_{i1})^2}{2} + (1-c_{i1})(c_{i1}-c_i) = \frac{(1-c_{i1})}{2}\left((1-c_{i1}) + 2(c_{i1}-c_i)\right) \\
w(c_i, c_{e2}) &= \frac{(1-c_i)}{2}\left((1-c_i) + 2(c_i - c_{i2})\right)
\end{aligned}
$$

Something to note here is that while clearly if we compare the monopoly cases we have the relationship, $w(c_i, c_e) < w(c_{i2}, c_e)$, that is the monopoly outcome with the lower price is better for both consumers and the firms. However, no analogous relationship exists between $w(c_i, c_{e2})$ and $w(c_i, c_{e1})$. If the gap $c_i - c_{i2}$ and $c_{i1} - c_i$ are equal then we have the relationship, $w(c_i, c_{e2}) > w(c_i, c_{e1})$. This is for the same reason as for the monopolist outcome, the price is lower without the profits being lower, therefore a net gain for consumers.

Before proceeding to analyze the innovations effect on welfare, we note that the welfare without the innovation is simply:

$$
w(c_i, c_e) + w(c_i, c_e) = \frac{3(1-c_i)^2}{4}
$$

0.6.1 Sequential

In the sequential innovation case with no buyout, in the firs time period there will be the competitive outcome with the incumbent ahead and in the second time period the entrant will be ahead with another competitive outcome. Necessarily the price will decrease, therefore for the consumers there will be an increase in surplus in the second time period.

$$
\begin{aligned}
\overline{W}_S = w(c_i, c_{e1}) + w(c_i, c_{e2}) &= \frac{1}{2}\left((1-c_{i1})\left((1-c_{i1}) + 2(c_{i1}-c_i)\right) + (1-c_i)\left((1-c_i) + 2(c_i - c_{i2})\right)\right) \\
&= 1 - \frac{c_{i1}^2}{2} + c_{i1}c_i - \frac{c_i^2}{2} - c_i(1-c_{i2}) - c_{i2} \\
&= 1 - \frac{c_{i1}^2}{2} - \frac{c_i^2}{2} - c_i(1 - c_{i2} - c_{i1}) - c_{i2}
\end{aligned}
$$

When the buyout occurs there is always a monopoly. So the consumers will simply have to deal with the default monopoly in the first period and with the lower cost monopoly in the second period.

$$W_S = w(c_i, c_e) + w(c_{i2}, c_e) = \frac{3}{8}\left((1-c_i)^2 + (1-c_{i2})^2\right) \tag{0.6.1}$$

0.6.2 Radical

Welfare when the radical innovation is pursued and there is no buyout is similarly given by:

$$\begin{aligned}\overline{W}_R &= q2w(c_i, c_{e2}) + (1-q)(w(c_i, c_e) + (1-q)w(c_i, c_e) + qw(c_i, c_{e2}))\\ &= qw(c_i, c_{e2})(3-q) + (1-q)w(c_i, c_e)(2-q)\\ &= \frac{1}{8}(1-c_i)\left(6 - c_i\left(7q^2 - 21q + 6\right) - (1-8c_{i2})q^2 - 3(8c_{i2}-1)q\right)\end{aligned}$$

If buyouts do occur and we are in the monopoly paradigm, the consumers are always in facin high prices but have a preference for the innovation to occur, the welfare when there are buyouts is given by the expression:

$$\begin{aligned}W_R &= qw(c_{i2}, c_e)(3-q) + (1-q)w_{m1}(2-q)\\ &= \frac{3}{8}\left((c_i-1)^2(2-q)(1-q) + (c_{i2}-1)^2(3-q)q\right)\end{aligned}$$

Appendix 2: Welfare results

Proposition 12. *The welfare maximizing choice in the case of buyouts is identical to the entrant's optimal choice in the case of no buyout and the incumbents ex-ante choice.*

0.6.3 Proof of proposition 12

Proof.

$$
\begin{aligned}
W_R &> W_S \\
qw(c_{i2}, c_e)(3-q) + (1-q)w(c_i, c_e)(2-q) &> w(c_i, c_e) + w(c_{i2}, c_e) \\
w(c_{i2}, c_e)(q(3-q)-1) + w(c_i, c_e)((1-q)(2-q)-1) &> 0 \\
w(c_{i2}, c_e)(3q-q^2-1) + w(c_i, c_e)(1-3q+q^2) &> 0 \\
w(c_{i2}, c_e)(3q-q^2-1) - w(c_i, c_e)(3q-q^2-1) &> 0
\end{aligned}
$$

If the costs are the same, then radical will be preferred if:

$$q > \frac{3-\sqrt{5}}{2} \tag{0.6.2}$$

Which is identical to the cutoff point for the entrant to prefer the radical innovation.

□

In proposition 12 we look for the criterion under which welfare is maximized when **buyouts occur** and show that they are identical to the profit maximizing criterion of the entrant when **buyouts do not occur** and the ex-ante case. To state this another way, if absent a buyout, the entrant chooses the radical innovation, then, if there are buyouts, the welfare maximizing choice is also the radical innovation.

Proposition 13. *A necessary(but not sufficient) condition for the radical innovation to be welfare maximizing is that* $w(c_i, c_{e2}) + w(c_i, c_{e1}) - 2w(c_i, c_e) > 0$. *Similarly for it to be possible that sequential innovation is welfare maximizing it must be that:* $w(c_i, c_{e1}) - w(c_i, c_{e2}) > 0$

Proof.

$$
\begin{aligned}
\overline{W}_R &> \overline{W}_S \\
qw(c_i, c_{e2})(3-q) + (1-q)w(c_i, c_e)(2-q) &> w(c_i, c_{e1}) + w(c_i, c_{e2}) \\
w(c_i, c_{e2})(3q-q^2-1) + w(c_i, c_e)(2-3q+q^2) - w(c_i, c_{e1}) &> 0 \\
q^2(w(c_i, c_e) - w(c_i, c_{e2})) - 3q(w(c_i, c_e) - w(c_i, c_{e2})) - w(c_i, c_{e2}) + 2w(c_i, c_e) - w(c_i, c_{e1}) &
\end{aligned}
$$

$$\rightarrow q > \frac{3}{2} - \frac{\sqrt{w(c_i, c_e) - 5w(c_i, c_{e2}) + 4(w(c_i, c_{e1}))}}{2\sqrt{(w(c_i, c_e) - w(c_i, c_{e2}))}}$$

So the bound for the expression to be smaller than 1 is:

$$\begin{aligned}
\frac{\sqrt{w(c_i, c_e) - 5w(c_i, c_{e2}) + 4(w(c_i, c_{e1}))}}{\sqrt{(w(c_i, c_e) - w(c_i, c_{e2}))}} &> 1 \\
w(c_i, c_e) - 5w(c_i, c_{e2}) + 4(w(c_i, c_{e1})) &> (w(c_i, c_e) - w(c_i, c_{e2})) \\
w(c_i, c_{e1}) - w(c_i, c_{e2}) &> 0
\end{aligned}$$

Similarly for the expression to be larger than 0 we must have:

$$\begin{aligned}
\frac{\sqrt{w(c_i, c_e) - 5w(c_i, c_{e2}) + 4(w(c_i, c_{e1}))}}{2\sqrt{(w(c_i, c_e) - w(c_i, c_{e2}))}} &< \frac{3}{2} \\
w(c_i, c_e) - 5w(c_i, c_{e2}) + 4(w(c_i, c_{e1})) > 9(w(c_i, c_e) - w(c_i, c_{e2})) \\
4(w(c_i, c_{e2}) + w(c_i, c_{e1})) - 8w(c_i, c_e) &< 0 \\
w(c_i, c_{e2}) + w(c_i, c_{e1}) - 2w(c_i, c_e) &< 0
\end{aligned}$$

$\square$

Bibliography

Aghion, P., Bloom, N., Blundell, R., Griffith, R., and Howitt, P. (2005). Competition and innovation: An inverted U relationship. The Quarterly Journal of Economics, 120(5):701–728.

Aghion, P., Harris, C., Howitt, P., and Vickers, J. (2001). Competition, imitation and growth with step-by-step innovation. Review of Economic Studies, 68(3):467–492.

Aghion, P., Harris, C., and Vickers, J. (1997). Competition and growth with step-by-step innovation: An example. European Economic Review, 41(3-5):771–782.

Bena, J. and Li, K. (2014). Corporate Innovations and Mergers and Acquisitions. Journal of Finance, 69(5):1923–1960.

Bessen, J. E. and Maskin, E. S. (2009). Sequential innovation, patents, and imitation. SSRN Electronic Journal, 40(4):611–635.

Cabral, L. (2003). R & D competition when firms choose variance. Journal of Economics and Management Strategy, 12(1):139–150.

Comanor, W. S. and Scherer, F. (2013). Mergers and innovation in the pharmaceutical industry. Journal of Health Economics, 32(1):106–113.

Gerpott, T. J. (1995). Successful integration of R & D functions after acquisitions : An exploratory empirical study. Management, 25(2):161–178.

Gilbert, R., Riis, C., and Riis, E. (2016). Stepwise Innovation by an Oligopoly. Working Paper, pages 1–18.

Hart, O. D. and Moore, J. (1999). Foundations of Incomplete Contracts. The Review of Economic Studies, 66(1):115–138.

Haucap, J., Stiebale, J., and Stiebale, J. (2016). How mergers affect innovation: Theory and evidence from the pharmaceutical industry. IDEAS Working Paper Series from RePEc.

H.Demsetz (1972). Competition and growth with step-by-step innovation: An example. Journal of Legal studies, 1(1):13–28.

Higgins, M. J. and Rodriguez, D. (2006). The outsourcing of R&D through acquisitions in the pharmaceutical industry. Journal of Financial Economics, 80(2):351–383.

Jehiel, P. and Moldovanu, B. (2005). Allocative and informational externalities in auctions and related mechanisms. Governance and the Efficiency of economic systems.

Kuechle, G. and Rios, D. (2012). The Coase theorem reconsidered: The role of alternative activities. International Review of Law and Economics, 32(1):129–134.

Phillips, G. M. and Zhdanov, A. (2013). R&d and the incentives from merger and acquisition activity. The Review of Financial Studies, 26(1):34–78.

White, L. J. (2002). Trends in aggregate concentration in the united states. Journal of Economic perspectives, 16(4):137–160.

Zhao, X. (2009). Technological Innovation and Acquisitions. Management Science, 55(7):1170–1183.