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Preemptive Search and R&D Clustering Revisited.

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DISCUSSION PAPER

Preemptive Search and R&D Clustering Revisited

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Abstract

The results obtained by Cardon and Sasaki (1998) on R&D clustering are derived under the speci…c assumption that …rms only can own one patent. When multiple patents are allowed, R&D clustering will come about more frequently if search costs are substantial.

Keywords: R&D clustering; persistence of monopoly
JEL classi…cation: L12

1 Introduction

In a recent article, Cardon and Sasaki (1998) investigate the problem of choosing between multiple R&D paths. Firms essentially have two possible strategies to deal with two di¤erent R&D projects available simultaneously. Either they will take up the same research project (cluster) or they will follow a di¤erent path (separate). In the clustering case, there can only be one winner of the R&D game. That …rm is rewarded a patent, so it earns the monopoly pro…ts in the market, but just for one period because afterwards the loosing …rm takes up the project left previously not researched. After completing the left-over project, the

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market structure changes into duopoly since the projects lead to new products that compete with each other for consumers. In the separation case where a coordinating device assures that each firm chooses a different project, the firms each own a patent on a new technology and hence become duopolists right away.

Cardon and Sasaki then show that the strategy of tackling first one and the same project (i.e. R&D clustering) can be explained by the desire of firms to collude stochastically. This is indeed what happens when by tossing a coin the patent officer decides to grant the rights to one of the two claimants each of them having pursued the same research avenue. They then make explicit the circumstances where it pays to target the monopoly profits for one period rather than the duopoly outcome, although it is clear a priori that only one firm can be lucky in getting a one period monopoly position.

From intuition, it already is obvious that the willingness to engage in such a clustering strategy on the one hand will depend on the availability of a rescue possibility or safety net for the firm who happens to loose the coin tossing game played by the patent officer. In the present paper, it is argued that the project left alone by the firms in the previous stage cannot fully act as a rescue device to the unlucky firm, because there is no reason to believe that this project will be exclusively available to this firm. On the contrary, the lucky winner of the coin tossing game will be at least as interested in this project since to him it is an opportunity to extend his monopoly profits. This possibility on the other hand then is an element that makes the clustering strategy more appealing.

Moreover, it can be the case that the loosing firm does not find it attractive to develop the remaining technology because the expected duopoly pro…ts fall short of the R&D costs. In that case the winner of the …rst stage remains a monopolist forever, without even doing R&D on the project not yet developed. A priori, it is unclear which e¤ect will dominate and therefore it is worthwhile to investigate in more detail the direction and magnitude of these forces.

In order to do this, the paper is organized as follows: the next section reconsiders the Cardon and Sasaki model and proves a lemma and two propositions. The lemma identi…es a condition © which is crucial for what happens in the subgame that starts after …rms decided to cluster in the …rst stage. The …rst proposition compares the payo¤s for clustering with those of a separate strategy when no patent law restrictions are involved. The second proposition shows the direction of the bias when such laws are unrealistically invoked. A third section concludes while o¤ering some thoughts on relating some of the recent …ndings to an existing literature on the persistency of monopoly and sequential innovation.

2 The Simplest Model of Search Paths Reconsidered

Two a priori identical …rms can tackle two di¤erent potential technologies that, when developed, are separately patentable but produce substitute products. Nothing prevents a …rm to pursue a patent portfolio strategy, that is to own the claims on more than one technology. For the remainder, all the assumptions and notation in Cardon and Sasaki are maintained.

Now consider the subgame that results after players have chosen to cluster and the patent officer has tossed the coin to determine the winner of the R&D game. A crucial inequality to hold is $C \leq \frac{1}{2}\sum_{t=1}^{\infty}\delta^t\Pi_2$ (condition Φ). This condition assures that the loosing firm will remain interested in the project not yet researched, when it knows that the winning firm also may capture the remaining innovation. Indeed, the following lemma can be shown:

Lemma 1 Either (i) both firms cluster on the remaining technology or (ii) no firm at all develops this technology.

Proof. Proof: W.l.o.g. assume firm 1 was lucky to win the patent on technology A. Further note that either $C \leq \frac{1}{2}\sum_{t=1}^{\infty}\delta^t\Pi_2$ (condition Φ) or the reverse (condition $\neg\Phi$) holds. If Φ holds, the looser will develop the remaining technology but then a fortiori the winner also will develop this technology implying (i). To show this formally note that firm 1 (the monopolist) has two alternatives. Either it "sits" and then it will earn from the next period on the duopoly profit Π_2 per unit of time, or the overall amount $\sum_{t=1}^{\infty}\delta^t\Pi_2$: As an alternative, the monopolist could develop the technological path left over, that is project B. Expected profits resulting from such a strategy are $-C+\frac{1}{2}\left(\sum_{t=1}^{\infty}\delta^t\Pi_1+\sum_{t=1}^{\infty}\delta^t\Pi_2\right)$: The difference clearly is $-C+\frac{1}{2}\left(\sum_{t=1}^{\infty}\delta^t\Pi_1-\sum_{t=1}^{\infty}\delta^t\Pi_2\right) \geq -\frac{1}{2}\sum_{t=1}^{\infty}\delta^t\Pi_2+\frac{1}{2}\left(\sum_{t=1}^{\infty}\delta^t\Pi_1-\sum_{t=1}^{\infty}\delta^t\Pi_2\right)=\frac{1}{2}\sum_{t=1}^{\infty}\delta^t\Pi_1-\sum_{t=1}^{\infty}\delta^t\Pi_2=$

$\frac{1}{2}\sum_{t=1}^{\infty}\delta^t(\Pi_1-2\Pi_2) \geq 0$; where the first inequality results from replacing the cost of the project by the profits necessary to get firm 2 started, that is the assumption that condition Φ holds. The second inequality follows from the fact that any duopolistic market structure can at most yield half of the monopoly profits. Firm 1 therefore will expect more from trying to continue his monopoly position and thus will start researching the remaining project rather than "sit", hence (i). If condition n© holds, the loosing …rm quits and …rm A remains a monopolist who doesn't need to develop the remaining technology either, proving (ii). ■

The implication of lemma 1 is that a …rm who is unfortunate in a clustering strategy will not simply earn $\sum_{t=1}^{\infty} \delta^t \pi_2$ if it sinks C;as assumed by Cardon and Sasaki. Since Gilbert and Newbery (1982), it is known that incumbent monopolists have stronger incentives than outsiders to acquire non-drastic innovations, both with a deterministic and a stochastic R&D technology as shown by Yi (1995). Hence, once two …rms have clustered on a research project, they will also cluster on the remaining one, unless some exogenous fact prevents them from owning more than one patent. This implies that the equilibrium payo¤s for the clustering case are di¤erent from those put forward by Cardon and Sasaki, and a fortiori that the comparison between clustering or following a di¤erent research strand is not entirely accurate. Indeed, at the outset when deciding between a di¤erentiated versus a clustered technological path, …rms will take into account that they only will earn $-C + \frac{1}{2} \sum_{t=1}^{\infty} \delta^t \pi_2$ when they loose the …rst round in the clustering strategy. This expression either is positive (condition ©), but then there will be competition on the remaining project, or it is negative (condition n©) ensuring that the monopoly lasts forever.

Before entering into a formal comparison between clustering and a separate R&D strategy, it is useful to summarize the elements that will matter. First, when condition © holds: in favor of clustering is the possibility that one has two successes in a row and earns the monopoly pro…ts forever. Against clustering is the fact that the rescue net is not exclusively available to the looser of the …rst stage while …rms in addition have to realize that no matter what the outcome of the …rst project is, they also have to engage in the second project and hence must incur twice the search costs. A priori, it is not clear that one of these e¤ects should dominate over the others. Next, when the looser is preempted (condition n© holds), clustering implies giving up a certain duopoly pro…t for the chance of becoming a monopolist forever. Since these duopoly pro…ts tend to be to low (expected duopoly pro…ts are not su¢cient to cover up for the R&D costs), there is a presumption that trying to become a monopolist forever and hence following a clustering strategy could be the best thing to do. In any case, the stake is an extension of the monopoly position beyond period two. Either by preemption or by being lucky twice in a row, clustering opens the perspective to earn the monopoly pro…ts forever.

A formal comparison of the overall payo¤s of the game enables to prove the following proposition.

Proposition 2 (i) Whenever it is the case that condition n© holds, regardless the magnitude of the duopoly pro…ts, the search costs or the level of the discount factor, the …rms choose a shared path in any pure strategy equilibrium. (ii) Whenever condition © holds, the …rms in any pure strategy equilibrium only choose a separate path when the product market structure is not too competitive and the discount factor not too high.

Proof. First consider the case where condition n© applies. The di¤erence in expected profits between the shared and the separate paths is: $-C + \frac{1}{2}\sum_{t=1}^{\infty}\delta^t\Pi_1 - \left(-C + \sum_{t=1}^{\infty}\delta^t\Pi_2\right) = \sum_{t=1}^{\infty}\delta^t\left(\frac{1}{2}\Pi_1 - \Pi_2\right) \geq 0$; again by the fact that a duopolistic market structure can yield at most half of the monopoly profits. So when condition nΦ holds, following a shared path strategy yields at least as much profits than following a separate strategy, proving (i). Next consider the case where condition Φ applies. When firms follow a differentiated research strategy, they will earn $-C + \sum_{t=1}^{\infty}\delta^t\Pi_2$. If they on the contrary decide to cluster, they can expect: $-C - \delta C + \frac{1}{2}\delta\Pi_1 + \frac{1}{4}\sum_{t=2}^{\infty}\delta^t\Pi_1 + \frac{1}{2}\sum_{t=2}^{\infty}\delta^t\Pi_2$: The difference (shared-separate path) is $-C - \delta C + \frac{1}{2}\delta\Pi_1 + \frac{1}{4}\sum_{t=2}^{\infty}\delta^t\Pi_1 + \frac{1}{2}\sum_{t=2}^{\infty}\delta^t\Pi_2 - \left(-C + \sum_{t=1}^{\infty}\delta^t\Pi_2\right) = -\delta C + \delta\left(\frac{1}{2}\Pi_1 - \Pi_2\right) + \frac{1}{2}\sum_{t=2}^{\infty}\delta^t\left(\frac{1}{2}\Pi_1 - \Pi_2\right) = -\delta C + \delta\left(\frac{1}{2}\Pi_1 - \Pi_2\right) + \frac{1}{2}\delta^2\frac{\frac{1}{2}\Pi_1 - \Pi_2}{\delta - 1}$: A separate strategy then will be followed iff simultaneously the following two conditions are satisfied:

(condition Φ): $-C + \frac{1}{2}\sum_{t=1}^{\infty}\delta^t\Pi_2 = -C + \frac{1}{2}\Pi_2\frac{\delta}{1-\delta} \geq 0$

(condition Ψ): $-\delta C + \delta\left(\frac{1}{2}\Pi_1 - \Pi_2\right) + \frac{1}{2}\delta^2\frac{\frac{1}{2}\Pi_1 - \Pi_2}{1-\delta} < 0$

In order to satisfy both Φ and Ψ it is clear that the product market structure cannot be too competitive and the discount factor not too high as becomes clear from substituting $\Pi_2 = 0$ and $\delta = 1$ in respectively Φ and Ψ, each time resulting in a violation of the respective constraint, proving (ii). ■

Proposition 1 is not intended to create the impression that the scope of a separate R&D strategy rather is limited and hence that properly taking into account the fact that a monopolist can tackle research avenues previously disregarded, increases the attractiveness of R&D clustering. The range of parameter values sustaining a separate research strategy has to be compared to the range obtained by Cardon and Sasaki to conclude wether the possibility to extend the monopoly position over-or undercompensates for the reduced possibility of a safety net and the additional search costs. But it certainly is the case that part (i) of proposition 1 identifies a range for the cost parameter that induces clustering and that is absent when firms only may own one patent. Next we provide a full characterization of the optimal R&D strategies in function of the cost parameter C.

The approach is to simplify the model even further. In that respect it is useful to note that the analysis above can be carried out in a two-period model without loosing a single detail of the argument. In addition, a two period model allows for bounded profits in the presence of no discounting. While not strictly needed, assuming $\delta = 1$ allows an easy and entirely complete characterization of the optimality of the respective R&D strategies in function of the search costs.

In such a two period world, the conditions derived by Cardon and Sasaki to distinguish between separated and clustered R&D identically remain the same. In the model that allows for patent portfolio's that has been presented here, the key conditions read:

(condition α') $C \leq \frac{1}{2}\Pi_2$

(condition β') $C > \left(\frac{1}{2}\Pi_1 - \Pi_2\right) + \frac{1}{2}\left(\frac{1}{2}\Pi_1 - \Pi_2\right) = \frac{3}{4}(\Pi_1 - 2\Pi_2)$

Therefore:

Proposition 3 Whenever feasible, a separate strategy becomes less likely in a scenario where firms may own patent portfolio's when search costs are substantial, while a separate strategy will be followed more often in the presence of lower search costs.

Proof. According to Cardon and Sasaki, a necessary and sufficient condition for a separate R&D strategy is that $2\pi_2 \geq C > \pi_1 - 2\pi_2$; where the first inequality is due to the fact that a separate R&D strategy has to yield positive profits. When patent portfolio's are allowed, a separate strategy only comes about when: $\frac{1}{2}\pi_2 \geq C > \frac{3}{4}(\pi_1 - 2\pi_2)$: These regions are assumed to be non-empty, which implies that π_2 cannot be too small. More precisely, a sufficient condition to allow for the possibility of a separate strategy both with and without restrictions on holding patents is: $\pi_2 > \frac{3}{8}\pi_1$: It then is easy to note that $2\pi_2 > \frac{1}{2}\pi_2$; whereas $\frac{3}{4}(\pi_1 - 2\pi_2) < 1(\pi_1 - 2\pi_2)$. Clearly, these last inequalities put less restrictions on the level of the costs from below (meaning that a separate strategy already will come about at lower cost levels), but more restrictions on the level of costs from above (meaning that the separate strategy will vanish sooner as R&D cost rises, to become a clustered strategy).

■

It is easy to show that these results nowhere depend on the assumption that $\delta = 1$. Again proposition 2 is backed by intuition: substantial research costs quickly imply preemption. As shown, this entails an advantage in favor of a clustered strategy, especially because the persistence of monopoly comes without incurring the search costs twice. When search costs are lower, a clustered strategy still has to some extent an (incomplete) preemptive effect but at the cost of incurring the search costs twice, making it less appealing.The results obtained in relation to Proposition 2 can be summarized by means of a figure indicating the optimal research strategy as a function of the level of the costs C.

Figure 1. A comparison of equilibrium R&D strategies in function of R&D costs

CCCCCCCCCCCCSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSS//////////////////

j———j————j——————j—————————j——j——| COST

0 3/4(¦1 ¡ 2¦2) (¦1 ¡ 2¦2) 1/2¦2 2¦2 ¦1

CCCCCCSSSSSSSSSSSSSSSSSSSSSSSCCCCCCCCCCCCCCCCCCCCC/////////

The interpretation is simple: a "C" denotes that the equilibrium strategy is to cluster, an "S" indicates that it is better to separate and finally "/" denotes no R&D undertaken. On top is the outcome predicted by Cardon and Sasaki while below the results from the present paper are illustrated. As already argued, when firms may own more than one patent costs cannot increase too much for clustering to outperform separation due to the duplication that necessarily follows in any clustering strategy. However, this conclusion certainly is not linear as claimed by Cardon and Sasaki in that clustering re-appears as the optimal outcome as soon as costs become big enough. Finally, figure 1 shows that ownership of multiple patents makes a difference regarding whether R&D will be done at all. The preemptive effect of high search costs adds to the appeal of a clustering strategy to such an extent that innovation is taken up beyond cost levels for which R&D is not sensible anymore if no multiple patents are allowed.

Given the above conclusion, there will be circumstances under which the market only will take up research activities if multiple patents may be owned. This leads to the well-known trade-off between static and dynamic efficiency. On the static side, it is best to have two innovators who then compete in the product market afterwards, at least when markups create dead weight losses. With restrictions on patent holding, this situation inevitably will come about, either directly when firms engage along the separate path, or after one period when they cluster. Without restrictions on patent holding, there is a danger of perpetual monopoly in one quarter of the cases when conditions © and nª hold simultaneously. In addition then, there is the unnecessary duplication of search costs inducing a welfare loss of 2±C: When condition n© holds, a monopoly will exist forever, but the search cost will only be incurred once. But, when these search costs are substantial, R&D will be taken up in cases where no R&D would be done in the absence of multiple patent ownership.

Therefore, the following recommendations for patent and technological policies can be formulated. If dead weight losses resulting from monopoly pricing tend to be small, for example due to very inelastic demand, while search costs are substantial, the static losses of monopoly can be compensated by the dynamic gain from getting the innovation. If static welfare losses from monopoly are substantial while the costs are not prohibitive, clustering should be avoided.

In this case now, clustering occurs when costs are low, calling for the eventual taxation of R&D expenditures. Moreover, for the results related to proposition 2, it is clear that clustering will take place more often when patent ownership is restricted. That is, taxation will need to be more severe. The general conclusion therefore tends to be that restricting patent ownership might not be such a good thing. Let alone for implementation motives left outside the scope of this paper such as the requirement that patent o¢cers can distinguish if one technology is a substitute for the other. It would require from them antitrust expertise to delineate the relevant market for a set of technologies.

3 Conclusion

In the present paper it has been argued that Cardon and Sasaki implicitly assume that the winner of a clustering R&D strategy cannot participate in further R&D races. This implies that there are restrictions on owning more than one patent. In the absence of such restrictions, one has to show endogenously that the winner of the …rst stage will "sit" on his innovation and remain inactive. This is not the case, on the contrary he will participate in the development of the research avenues left over in the …rst stages of a clustering strategy. This reduces the appeal of such a strategy by decreasing the importance of a rescue strategy and by inducing the duplication of costs. If however the search costs are substantial, it becomes possible that they act preemptively, adding to the appeal of a clustering strategy, the latter now entailing perpetual monopoly pro…ts without requiring twice the sinking of search costs.

As in much of the innovation literature, searching is assumed to be a sunk cost. Therefore, it is not surprising that general insights on the evolution of industry also apply to the present model. Sutton (1991) has clearly shown how industries characterized by high sunk costs together with low profits (either as the result of strong price competition and/or weak product differentiation) will remain monopolistic even tough the size of the market increases and hence entry opportunities occur. Related insights to those explored here also are to be found in the sequential innovation literature, see e.g. Vickers (1986), Green and Scotchmer (1995) and Gandal and Rockett (1995). More in particular the impact of product market competition on the persistency of monopoly is well documented. While in those papers innovation opportunities present themselves subsequently, Cardon and Sasaki have introduced a model where sequential searching for innovation is an endogenously determined outcome, namely if firms choose to cluster rather than separate. But in analyzing the equilibrium outcome, the economic forces analyzed in the sequential innovation literature should be taken into account. If this is done, the result by Vickers that competitive market structures (for instance homogeneous Bertrand competition) lead to increased dominance is reconfirmed. Indeed, strong competition induces clustering which is associated with the persistence of monopoly. But also the threat of the future erosion of monopoly profits as documented by Green and Scotchmer has its influence. If search costs are substantial, the fact that also the winner of the first patent will race for the second influences the decision to cluster.

These forces will also affect the analysis of the many interesting extensions considered by Cardon and Sasaki. For example consider the case of more …rms and more paths. Since there exist circumstances in which all …rms will search on all projects, a novel question is whether they do this simultaneously or sequentially. In the …rst case they all immediately will sink mC, where m denotes the number of projects, while in the other case they will tackle a project, observe the outcome and continue until a duopolistic market structure exists. Preliminary calculations indicate that the latter is the optimal strategy.

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