



DRUID Working Paper No. 13-11

Cannibalization, Innovation and Spin-outs

By

James D. Campbell and April Mitchell Franco

Danish Research Unit for Industrial Dynamics

www.druid.dk



Cannibalization, Innovation and Spin-outs

James D. Campbell
University of Toronto

April Mitchell Franco
University of Toronto
E-mail: April.Franco@Rotman.Utoronto.Ca

April 30, 2013

Abstract:

When an idea for a new product arrives, will it be developed and by whom? We develop a spatial model in which an idea arrives to a researcher within the firm. Products are imperfectly substitutable, so that developing a new product that is close to an existing product will cannibalize some amount of the existing product's sales, and the cost to develop a new product is higher the further it is from an existing product. Together these forces mean that there exist ideas that can be developed more efficiently by the researcher as a spin-out than by the firm (due to the cost of fit) but that the firm prefers to buy out the researcher and either develop itself or discard (due to the potential loss from cannibalization). These inefficient outcomes occur for ideas at intermediate distance from the firm's existing portfolio, and are likelier and more severe the higher is demand and the greater the degree of substitutability.

ISBN 978-87-7873-351-1

1 Introduction

How firms respond to competitive threats from other firms has been a subject of considerable interest both theoretically (Gilbert and Newbery, 1982; Reinganum, 1983, 1984; Cassiman and Ueda, 2006) and empirically (Chandy and Tellis, 2000; Christensen, 1997). In this paper we consider the firm's response to what is, in a sense, an internal competitive threat: an idea for a new product generated by a researcher working inside the firm and that, if developed, will to some degree cannibalize an existing product. The primary questions of interest are which ideas will be developed and by whom, and how the environment might affect the efficiency of the outcome.

Following Habib et al. (forthcoming), we use a spatial model in which consumers with unit demand are distributed throughout a product space; a consumer is willing to pay more for a product that is closer to her. This makes products substitutable: a consumer located 'between' two products will derive positive value from either one. First we consider a monopolistic incumbent who produces a single product, and has received an idea for a new product at a given distance from its existing offering. We show that there is a gap between products. The gap depends on the fixed cost of development and the substitutability between the two products. Substitutability means that the marginal return to developing this new product is higher the farther it is from the original product, and so the firm will develop the new product only if it sufficiently far away, with closer ideas being shelved. The gap is larger when the fixed cost of development is smaller and when the substitutability between the products is bigger. This provides a rationale for the existence of lumpiness and gaps in product space, as identified in de Figueiredo and Silverman (2007).

Next we study the effect of adding a cost of fit: products that are farther away from the firm's existing offering will cost more to develop. This could be due, for example, to 'closer' ideas being more easily developed using the firm's existing expertise, personnel or equipment, or more easily associated with the firm's existing brand. Substitutability led the firm to forgo development of ideas that were 'too close', while this fit cost naturally implies that the firm will also forgo development of ideas that are 'too far'. Together these imply that ideas within a 'window' at intermediate distance from the monopolist's current product will be developed, with the window depending on the cost of fit and the level of competition between the products. In a dynamic

setting, this would also be consistent with a firm expanding its portfolio of products in small increments rather than jumps. This provides the underpinnings for the model by connecting the cannibalization effect to the cost of development.

Further, we study what happens if when the firm chooses not to develop an idea, a competitor may emerge to develop it. If the new product is close enough that it is substitutable with the incumbent's product, and cannibalization causes a loss for the incumbent, there is an incentive for the firm to engage in defensive development even when developing the idea is not itself profitable.

With this framework in place we study a setting in which the incumbent monopolist employs a researcher to seek ideas. An idea arrives to the researcher, and ownership of this idea is contractible without frictions between the firm and researcher. There are three possible outcomes: it can be developed into a product by the firm, developed into a product by a spin-out firm created by the researcher, or discarded. The socially efficient outcome would be for ideas to be profitably developed by either the firm or the researcher, whichever of the two has lower cost, as long as the net surplus is positive.

This socially efficient outcome is not in general realized. For an idea that is sufficiently far from the incumbent's portfolio, the high cost of fit for the incumbent can mean that the idea may be more profitable for the researcher in a spin-out, or even that the idea may be profitable for the researcher as a spin-out and loss-making for the firm. In these cases the socially efficient outcome would be for the researcher to develop the idea. However, due to the substitutability between the two products, the incumbent would then endure lower profits on its existing product due to cannibalization. It may therefore prefer to 'buy' the idea from the researcher and either develop it internally or discard it than to endure this loss.

Inefficient outcomes can thus manifest as either ideas developed by a higher-cost incumbent (with foregone consumer surplus due to the suppression of competition between firms with substitutable products) or as wrongly discarded ideas (with foregone surplus in general). The first effect is well-known in the literature (Arrow, 1962), while the second effect has not been highlighted. In both cases consumers suffer a loss due to the foregone competitive pressure across product variety. We show that these inefficient outcomes are more likely at 'intermediate' distance from the existing product that would be cannibalized: for very close ideas, the marginal social value of

the idea is low because it is highly substitutable with an existing product, and for very far ideas, cannibalization is so low that the incumbent will not find it worthwhile to preclude development by a spin-out.

The likelihood of an inefficient outcome arising for a given idea, the range of distance across which inefficient outcomes arise, and the magnitude of the inefficiency when it occurs are all larger when demand is higher (reflecting a larger market or higher willingness to pay by consumers) and when products are more substitutable. This is since with higher demand, a newly introduced product will cannibalize more from the existing product and so the greater the incentive for the incumbent to engage in defensive action. Thus ideas that are more socially valuable are less likely to realize this social value.

Our work provides the microfoundations for understanding the product introduction choices made by firms in dealing both with competition between its own products and with competition that may arise from within the firm in the form of a spin-out. Given that the innovation that gives rise to a new product can be thought of as a patent, our work has important implications for anti-trust authorities, and encompasses that of Gilbert and Newbery (1982) since patenting can be thought of as a spatial game in the presence of substitutability. There are a number of papers that focus on the issue of sleeping patents and the impact on productivity as well as their anticompetitive effects (Palomeras, 2003); however, our work suggests that simply observing a patent in use is not enough to determine whether or not the outcome is efficient. It is possible that the “wrong” firm has developed the product, since it may have higher costs of introducing the new product and has done so only to defend its own products. In addition, we can also apply the model to other settings in which potential competitors transact over territory in product space. For example, an incumbent may seek to acquire a spin-out to avoid cannibalization by its products; while this may be an efficient reallocation of resources, our model suggests that there can exist cases in which adoption of the spin-out’s products or their scrapping by the incumbent may represent an inefficient outcome.

The remainder of the paper proceeds as follows. In Section 2, we develop the model and the monopolistic benchmark. Proposition 1 establishes which ideas the monopolist will choose to develop in the absence of potential competition. Section 3 introduces the notion of potential com-

petition, with Proposition 2 characterizing the monopolist’s incentives for defensive development of products. Section 4 introduces the researcher as the originator of the idea, and Proposition 3 characterizes the equilibrium outcome for an idea. Section 5 discusses the welfare implications of this result and presents Corollary 1 and 2 which address how the economic environment affects the efficiency of the market solution. Section 6 concludes.

2 Monopolist

2.1 Monopolistic firm developing a substitutable product

A monopolistic firm M produces a single product y_i . The subscript i denotes the location of product y in a one-dimensional product space. Consumers are uniformly distributed across product space with mass 1 at each point, and the willingness to pay for product i by a consumer at location z is

$$V(i, z) = \max\{\alpha - \beta|i - z|, 0\}. \quad (2.1)$$

That is, the consumer’s valuation of the product is decreasing in the distance between the consumer and the product. The higher is β , the greater the value loss to a consumer who uses a product at some given distance from her location. Each consumer has unit demand and will use at most one product. The parameter β can therefore be viewed as an inverse measure of substitutability across product space: the lower is β , the lower the premium a consumer at location l is willing to pay for product l over some ‘nearby’ product.

The monopolist can price discriminate and so extract the full willingness to pay $V(i, z)$ from each consumer. The firm’s total revenue from product i , denoted R_i , is the area of the triangle in Figure 1: $R_i = \frac{\alpha^2}{\beta}$.

Say now that the firm receives an innovation x_j . The firm can develop the innovation into a product y_j and add it to its portfolio of products, or do nothing and continue to sell only y_i . If the firm develops the innovation, its revenue will increase: since $j \neq i$, some consumers who had zero willingness to pay for product i will be willing to pay some positive amount for j . But if j is ‘close’ to i , then the products’ substitutability means that the marginal revenue from adding y_j

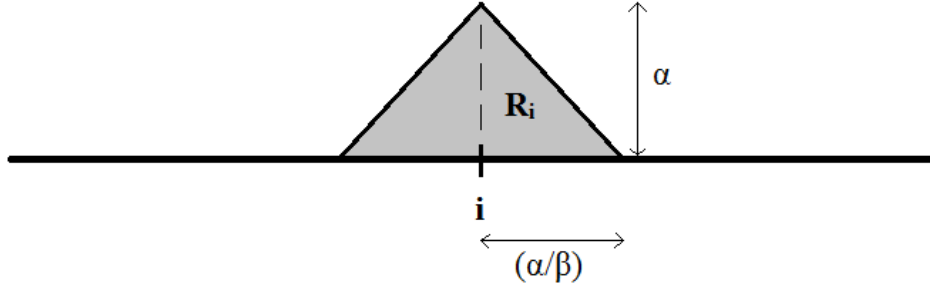


Figure 1: Willingness to pay for i by location

is less than R_i . This is illustrated in Figure 2, in which the darker shaded area A is the marginal revenue of introducing y_j .

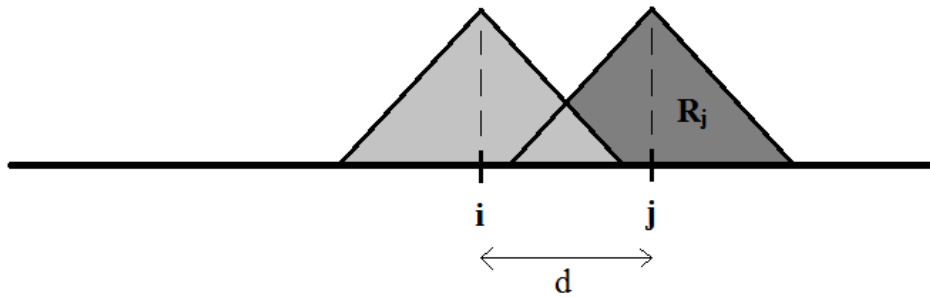


Figure 2: Marginal revenue to developing product x_j

Denote the distance $|i - j|$ by d_{ij} . Then the marginal revenue of introducing y_j , denoted $R_j(d_{ij})$, is:

$$R_j(d_{ij}) = \begin{cases} \alpha d_{ij} - \frac{1}{4}\beta d_{ij}^2 & \text{if } d_{ij} < \frac{2\alpha}{\beta} \\ \frac{\alpha^2}{\beta} & \text{if } d_{ij} \geq \frac{2\alpha}{\beta} \end{cases} \quad (2.2)$$

During that part of the domain of this function where $d_{ij} \in [0, \frac{2\alpha}{\beta}]$ —that is, where the products ‘overlap’ in the sense that there exist consumers who have positive willingness to pay for both products— $R_j(d_{ij})$ is increasing and convex, ranging from 0 when $d_{ij} = 0$ to $\frac{\alpha^2}{\beta}$ when $d_{ij} = \frac{2\alpha}{\beta}$.

Developing the innovation at j is costly. In particular, the cost of developing an innovation at

location j depends on the distance between j and the existing product produced by the monopolist. For example, the expertise that the firm already uses to produce product y_i may be more readily adapted to produce y_j if j is ‘close’ to i . In a more abstract sense the cost of fit could capture the riskiness of developing products that are very different from the firm’s existing line. Formally, the cost of developing the innovation is

$$c_j = F + \phi d_{ij}, \quad (2.3)$$

where $F \in (0, \frac{\alpha^2}{\beta})$ is a fixed component and $\phi > 0$ captures the cost of fit between the firm’s existing product and j .

If there was no substitutability between the old and new products, this cost structure would imply some maximum distance beyond which the innovation would not be developed. However, fit in conjunction with substitutability implies at best a ‘window’ in which the monopolist can profitably develop innovations. If the innovation is too close to i , substitutability means that marginal revenue is too low, but if the innovation is too far from i , poor fit means that development cost is too high¹.

The following result formalizes this notion:

Proposition 1. *If $\beta F > (\alpha - \phi)^2$, there exists no innovation x_j that the firm will develop. If $\beta F \leq (\alpha - \phi)^2$, then there exist \underline{d}, \bar{d} , where $\bar{d} \geq \underline{d} > 0$, such that the firm will develop x_j when*

$$d_{ij} \in [\underline{d}, \bar{d}], \quad (2.4)$$

and where \underline{d} is smaller and \bar{d} is larger

- i.** *the smaller is the fixed cost of development F ,*
- ii.** *the smaller is the cost of fit ϕ ,*
- iii.** *the greater is substitutability (smaller β), and*
- iv.** *the greater is demand magnitude α .*

¹Note that if there was no fit problem (if $\phi = 0$) then there would be a minimum distance such that the monopolist would develop the idea at j , but no maximum distance.

Figure 3 illustrates the window of profitable development.

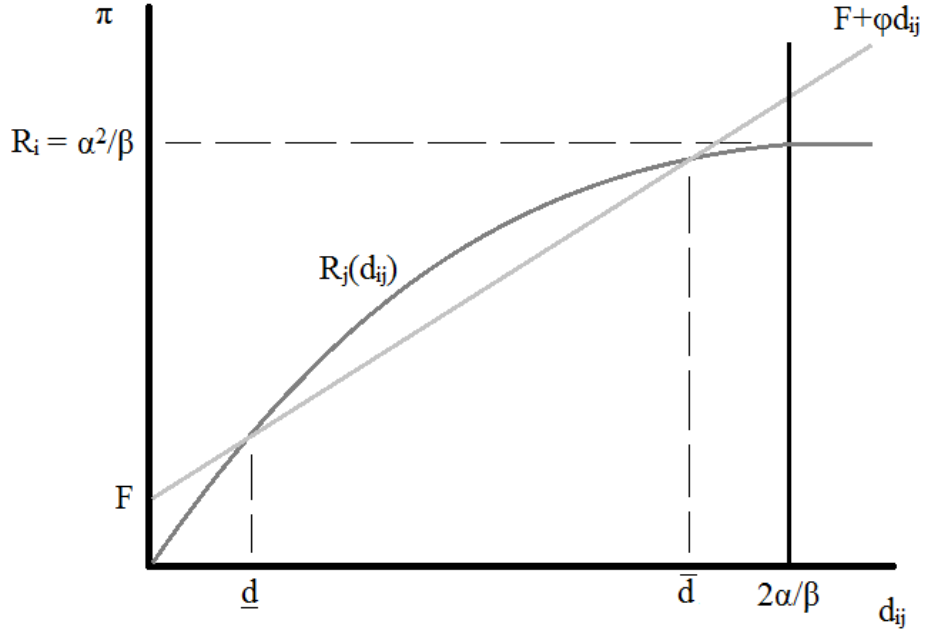


Figure 3: Profitable to develop x_j iff $d_{ij} \in [\underline{d}, \bar{d}]$

Proposition 1 establishes that this window is bigger when the fixed cost of development and the cost of fit are smaller, and when the parameters that capture the ‘size’ of demand are larger. An analogous result will hold from an initial state when the monopolist’s portfolio has more than one product; it will be profitable to develop within some window from the *closest* existing product.

The notion of fit implies a dynamic process by which successive innovations are either developed or not; an innovation that is far from the monopolist’s portfolio today (and thus not developed) may later be close as the portfolio expands. Proposition 1 therefore implies a process by which the monopolist’s product portfolio expands incrementally into new areas, rather than sudden jumps into new products that are far from its existing offerings. The maximal product variety across the product space at the end of such a repeated process of idea arrival is would be increasing in α , decreasing in β and decreasing in the cost parameters F and ϕ .

3 Potential competition

3.1 Entry and competition

So far we have considered the problem for a monopolist deciding whether to develop an innovation. This section will consider the problem for a potential competitor who must decide whether to enter the industry by developing a given innovation, and how this in turn affects the problem for the incumbent monopolist of the previous sections.

If a competitor develops a product sufficiently close to the incumbent's existing portfolio, there will be some consumers in an overlapping region who have positive willingness to pay for both products. We assume Bertrand competition over the common portion of this willingness to pay.

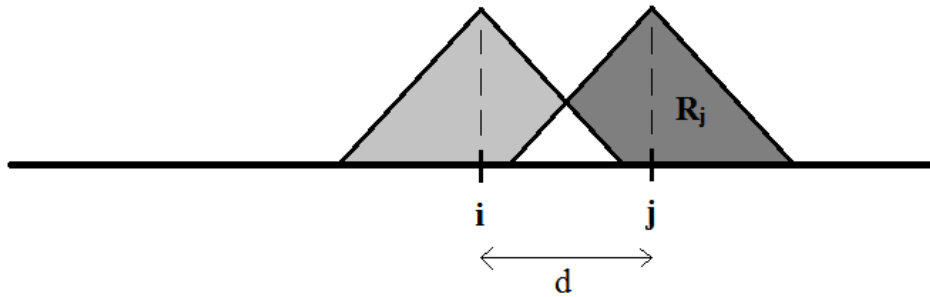


Figure 4: When an entrant develops at j , competition reduces surplus extracted from overlapping consumers

Figure 4 illustrates this competitive effect. If the entrant draws and develops an innovation at location j , then neither firm is able to extract from common consumers that portion of willingness to pay that is common to both firms. Thus the entrant earns R_j at j , but the revenue earned by the incumbent at i is also reduced in a manner that it was not in the case when the incumbent was itself the developer of j (as in Figure 2).

The revenue to the entrant from developing at j is identical to that earned by the monopolist. However, we allow for the possibility that the entrant faces a different cost of development; denote by E the fixed cost to the entrant of developing its first product. Again $E \in (0, \frac{\alpha^2}{\beta})$, but $E > F$, the fixed cost of development for the monopolist (equivalently, the monopolist's cost of development absent a cost of fit).

By analogy with the case of the monopolist with fixed development cost F , there thus exists d_E^0 such that when the incumbent is producing a product at i , the entrant will develop an innovation at j if and only if $d_{ij} > d_E^0$.

3.2 Potential entry and defensive development

Fix the incumbent's portfolio as a single product y_i . Consider the following game:

1. Innovation x_j is drawn by both the incumbent and entrant.
2. The incumbent chooses whether to develop product y_j .
3. The entrant observes the incumbent's decision and chooses whether to develop product y_j .

This is the simplest model of potential entry: an innovation at location j is 'in the air', and the incumbent firm may choose as before whether or not to develop it. However, now if the incumbent does not develop at location j , a potential entrant can choose whether to develop at the same location. The question of interest is how this potential entry changes the problem for the incumbent relative to that in Section 2.

Proposition 2. *The incumbent develops at j if and only if*

- i. $d_{ij} \in [\underline{d}, \bar{d}]$, or
- ii. $d_{ij} > d_E^0$ and $R_i > c_j$.

The first case in this result is that the incumbent will develop if it is unilaterally profitable to do so. But when there is potential entry there may be a larger region in which the incumbent will develop: the second case defines those innovations that would not be unilaterally profitable for the incumbent but that it will choose to develop defensively.

To see the reason for the second case, consider the situation in which the incumbent forgoes developing at a location that 'overlaps' its existing base and the entrant goes on to develop. The incumbent has foregone the marginal revenue of the new product (the area A in Figure 4) but has saved the cost of development c_j . But when the entrant develops, the incumbent also loses the area B in Figure 4 through competition between the products y_i and y_j . Thus the total loss to

not developing is $A + B = R_i$; if the saving c_j does not exceed this amount, the incumbent will develop, even if $R_j < c_j$.

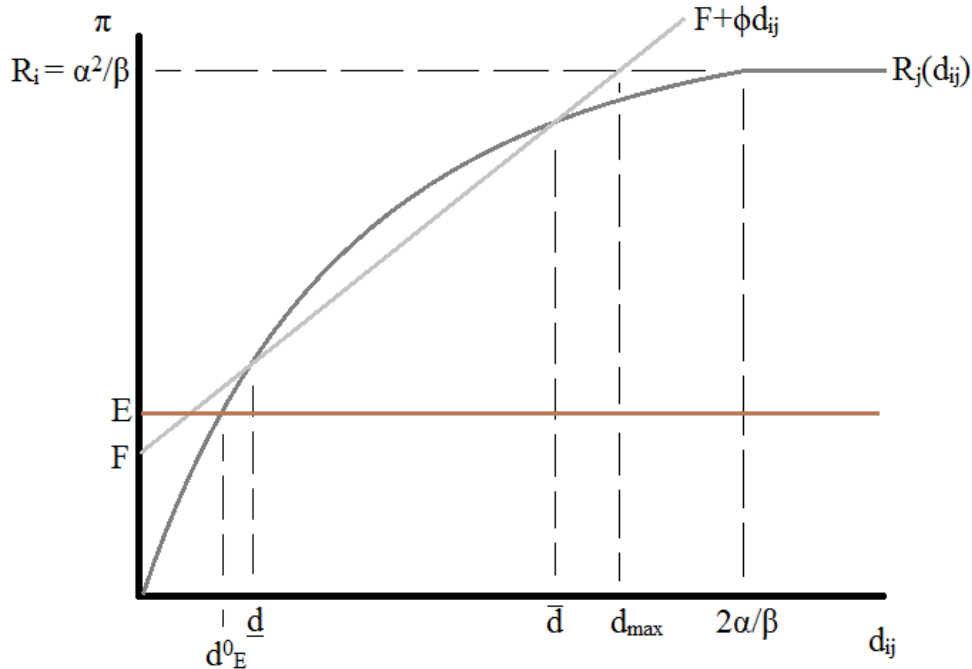


Figure 5: Incumbent will develop at j if $d_{ij} \in [d_E^0, d_{max}]$

Figure 5 illustrates how the window in which the incumbent is willing to develop can expand in the face of a potential entrant. Now the incumbent will prefer to develop any innovation x_j so that $d_{ij} \in [d_E^0, d_{max}]$. Thus the incumbent develops if the innovation arrives in this window, and the entrant develops if the innovation arrives so that $d_{ij} > d_{max}$. Note that it is in general possible that the window expands in both directions, either direction or neither direction, depending on E and the crossing point between c_j and R_i .

The conclusion of this simple incorporation of potential entry will generalize readily to a slightly different case. If the incumbent first draws an innovation at j and then the entrant draws from a distribution of possible innovations, it will again be the case that the incumbent may engage in defensive development, depending on the shape of the distribution from which the entrant will draw.

4 Researcher incentives

Next we add to the model the notion that an idea arrives to a specific researcher. If an idea arrives to a researcher who is employed by the incumbent firm, the firm may or may not elect to develop the innovation, but it also could be that the researcher ultimately develops the innovation outside the firm. This is related to the simple game in the previous section: depending on the institutional regime, if the firm passes on developing an idea x_j , the researcher could become an ‘entrant’ by taking the idea and developing it privately. We assume throughout that the arrival and location of an idea are known to both the researcher and the firm, so that there is no asymmetric information.

Say that initially the incumbent monopolist M employs a researcher S at a reservation wage of 0. When S receives an innovation at location j , then there are three broad possibilities for where this idea x_j ends up. First, the idea could be developed into product y_j by M . Second, it could be developed into y_j by S , outside the firm. Third, it could be discarded and developed by neither party. Assume for the moment that the researcher retains control of the idea when it arrives, so that she is free to leave and develop the idea privately should she so choose².

	Developed by S	Developed by M	Discarded
M 's payoff	$-(R_i - R_j)$	$R_j - c_j$	0
S 's payoff	$R_j - E$	0	0

Table 1: Marginal payoffs to the researcher and firm, gross of transfers

Absent any transfers between the researcher and the firm, Table 1 shows the payoffs to each party under each of these possibilities. The loss to the incumbent should the researcher ultimately develop at j outside the firm is precisely the area B in Figure 4.

Since the researcher has the ‘right of first refusal’ to the idea, should the firm want to develop or discard the idea, it must compensate the researcher to reflect that she could have developed the idea privately. This implies a game with the following order of play:

1. Innovation x_j is drawn by S .
2. M offers a payment $p \geq 0$ to retain S and x_j .

²This is without loss of generality to the ultimate outcome for the development of the idea, although it would not be to the contracting problem between the researcher and the firm. We discuss this in more detail in Section 5.

3. S accepts or rejects p .
4. **a)** If S accepts, p is transferred from M to S and M chooses to develop or discard x_j .
b) If S rejects, S chooses to develop or discard x_j .

This means that if the idea would be profitable for the researcher privately, the firm must pay at least $p = R_j - E$ (if this amount is positive) to satisfy the researcher's incentive compatibility constraint if it is to retain internally the right to develop idea x_j . In this case Table 2 shows payoffs net of the transfers that must take place in each case.

	Developed by S	Developed by M	Discarded
M 's payoff	$-(R_i - R_j)$	$E - c_j$	$-(R_j - E)$
S 's payoff	$R_j - E$	$R_j - E$	$R_j - E$

Table 2: Marginal payoffs to the researcher and firm, net of transfers

The following result then establishes the outcome for x_j in subgame perfect equilibrium.

Proposition 3. *In the game played by the firm and researcher:*

1. *Idea x_j is developed by the researcher if either*
 - a.** $E < R_j$, $c_j > R_j$ and $E < 2R_j - R_i$, or
 - b.** $E < R_j$, $c_j < R_j$ and $E < c_j - (R_i - R_j)$.
2. *Idea x_j is developed by the firm if either*
 - a.** $c_j < R_j$ and $E > R_j$, or
 - b.** $c_j < R_j$, $E < R_j$ and $E > c_j - (R_i - R_j)$.
3. *Idea x_j is discarded if either*
 - a.** $c_j > R_j$ and $E > R_j$, or
 - b.** $c_j > R_j$, $E < R_j$ and $E > 2R_j - R_i$.

Cases 2b. and 3b. are related to the defensive development observed in the model in Section 3.2. In both of those cases, the researcher could be profitable by developing the idea outside the firm, but the firm prefers and can afford to pay not to allow it. However, now there are two possibilities: the firm need not *develop* to defend, but as in 3b. can pay to retain and shelve the idea. The parameters of the model therefore enter into Proposition 3 in two distinct ways. For example, there are two broad effects of E . Larger E certainly makes it less likely that the researcher can profitably enter, but it also reduces the payment p that the firm must pay to retain the researcher and the idea.

5 Social welfare

The socially efficient outcome in this game would be for the idea developed if at least one of the firm or researcher can do so profitably, and if both could develop profitably, for the player with the lowest cost to develop. We can see this by appending Table 2 to include the payoff to consumers in each case:

	Developed by S	Developed by M	Discarded
M 's payoff	$-(R_i - R_j)$	$E - c_j$	$-(R_j - E)$
S 's payoff	$R_j - E$	$R_j - E$	$R_j - E$
Consumers' payoff	$R_i - R_j$	0	0
Sum of payoffs	$R_j - E$	$R_j - c_j$	0

Table 3: Payoffs to all parties, net of transfers

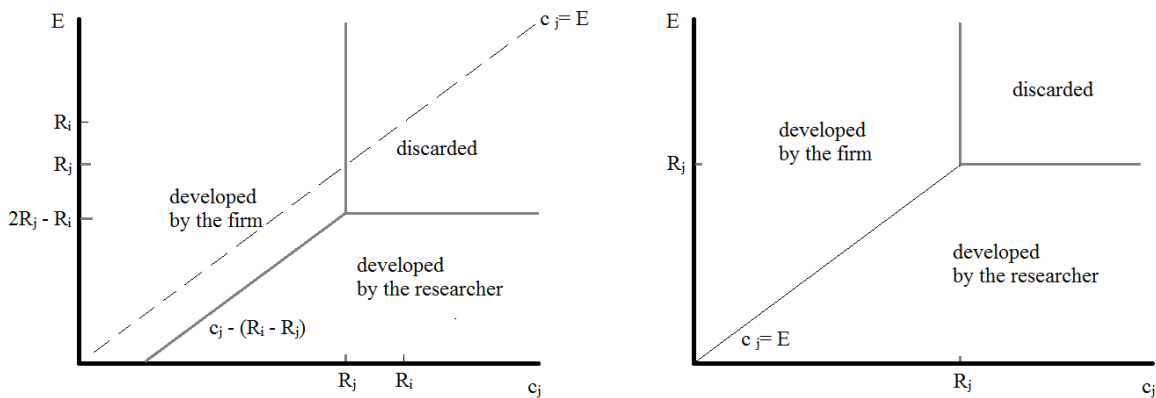
Proposition 3 demonstrates that the efficient outcome will not in general prevail so long as R_j is less than R_i ; that is, so long as the firm's original product and the idea at j are 'overlapping'. There are always cases in which an idea which 'should' be developed by the researcher is developed instead by the firm, and cases in which an idea 'should' be developed by the researcher and instead is discarded. In both cases the gain in consumer surplus due to competition between the two products is not realized; this is the area B in Figure 4. Consumers therefore bear the brunt of the welfare loss when an inefficient outcome prevails.

An implication of this result is that to tell whether 'good' use is being made of an idea, it is not sufficient just to observe whether or not it is being developed. Even in the simple environment of

the model, without contracting problems or other frictions, it can be that the firm that develops the idea has reached ‘too far’ into product space to develop it, in order to avoid the competitive loss from allowing the idea to be developed—at lower cost—elsewhere.

Since contracting between the firm and the researcher is frictionless, the outcomes in our model do not depend on the original ownership of the idea. Indeed, from the point of view of either the researcher or the firm, the efficient outcome prevails: regardless of whether the researcher or firm is granted ownership of the idea by the prevailing institutions or contracts, whichever of the two values the idea more highly ultimately controls it. As we have seen, this outcome is not in general socially efficient. This is because the social planner would consider the competitive loss to the firm in the case in which the researcher develops the idea not as a cost, but as a *transfer* to consumers, thus disconnecting the ‘efficient’ outcome of the firm and researcher’s bargaining from social efficiency. Therefore while the Coase Theorem applies in this setting to the bargaining process between the firm and researcher, the socially efficient outcome is not realized regardless of which of the two players has property rights to the idea.

The severity of the social inefficiency—the range of parameter values for which inefficient outcomes prevail—depends on the location of the idea. Figure 6 illustrates side-by-side the equilibrium and efficient outcomes for a ‘high value’ idea: one which is relatively ‘far’ from the firm’s original location.



(a) Equilibrium outcome (b) Socially efficient outcome
 Figure 6: Equilibrium and efficient outcomes for a ‘high value’ idea

We can see that there are regions in which an inefficient outcome is realized. For example,

the region in which an idea is discarded is larger than the efficient region. This is because in the extra area E is sufficiently low that the researcher could be profitable, but sufficiently high that the payment the firm has to make to retain and discard the idea (rather than suffer a competitive loss) is low.

But the closer the idea is to the firm's original location, the more severe the discrepancy. Figure 7 repeats the previous exercise for an idea that is close to the original location and so of 'low value'.

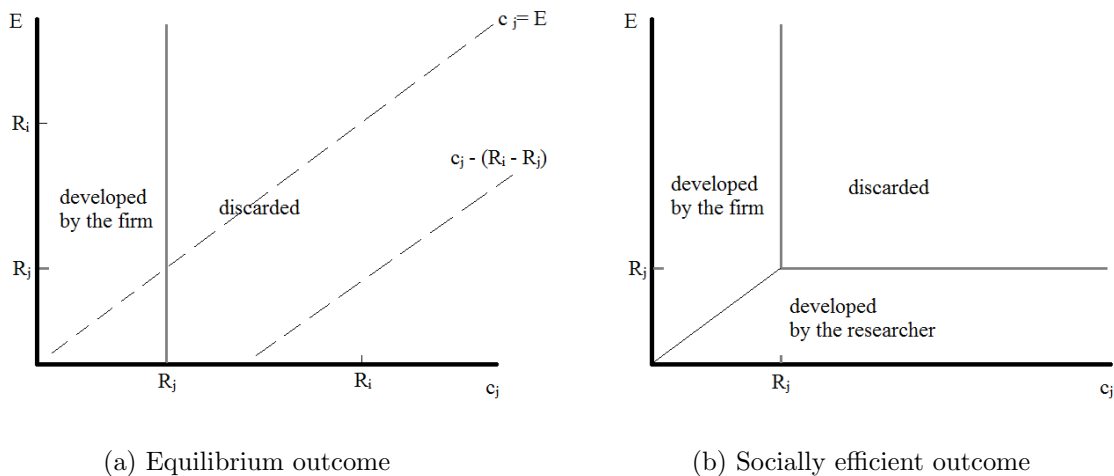


Figure 7: Equilibrium and efficient outcomes for a 'low value' idea

The closer the idea, the larger the region of inefficient outcomes: the potential payoff to the researcher by developing privately is small, and so the firm can cheaply buy out the idea to avoid the competitive loss or realize the gain itself. The parameter region in which we would observe a researcher leave the firm to develop her idea is also being squeezed. This may imply an inefficiently small product variety, as 'close' ideas may be underdeveloped, especially if the fit problem is high.

Figure 8 repeats the exercise of the previous figures, but for arbitrarily fixed values of the cost and demand parameters and variable distance. The numbered regions correspond to the numbered outcomes in Proposition 3, so that the region 3b and the portion of 2b in which $c_j > E$ correspond to the cases in which it is socially efficient that the researcher develop her idea, but the firm develops it (2b) or it is discarded (3b).

These inefficient outcomes appear for ideas that are neither too close nor too far from the original product i . For very close ideas (regions 3a and 2a), the fit problem for the incumbent is low and so its development cost is low relative to the cost for the researcher to set up: either

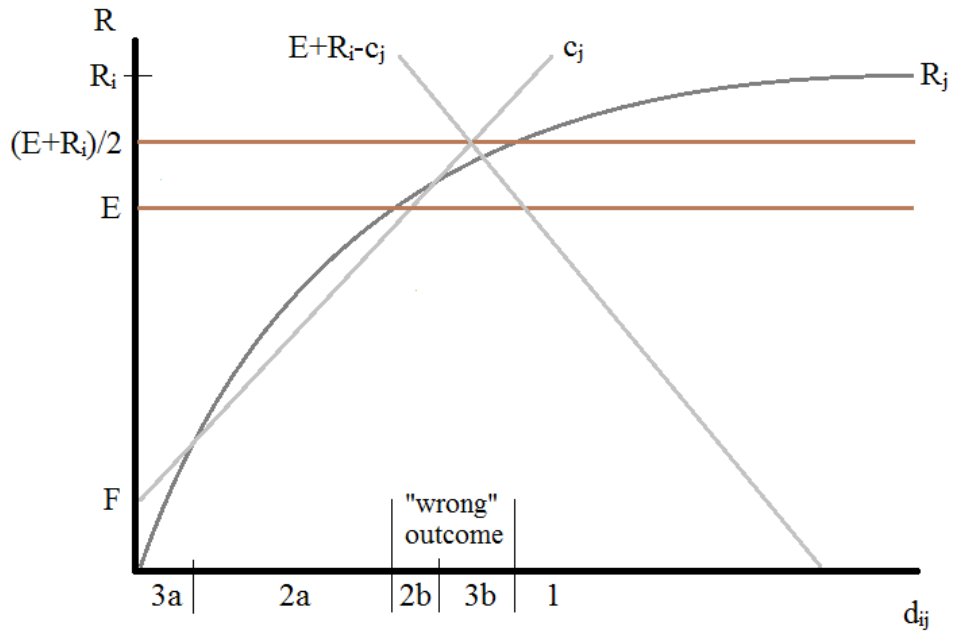


Figure 8: Inefficient outcomes occur at intermediate distance

the idea is too close to be usable or it is (efficiently) developed by the firm. For very far ideas (region 1), the fit problem is more severe for the incumbent, it is very expensive for the incumbent to buy the idea from the researcher, since the profitability of the idea is high, and the loss to the incumbent is relatively small. It is therefore efficient that the researcher develop the idea privately. Between these two regions, the fit problem is severe enough so that the startup would be more efficient, but the loss to the incumbent from allowing the startup is still high enough and the cost to buy the idea still low enough that the incumbent prefers not to allow the researcher to develop privately.

5.1 Social efficiency and market demand

We can also consider how the outcome for an idea depends on the demand parameters α and β . There are two relevant effects of higher demand parameters (for a given idea location). First, the loss endured by the incumbent when the researcher develops the idea is larger since there is more scope for cannibalization. Second, it is more costly for the incumbent to discard the idea, since its value to the researcher is higher and therefore more compensation must be paid. We can see these

effects in Table 3: for higher demand parameters, M 's payoff is lower in both the case in which the idea is developed by S and the case in which it is ultimately discarded.

This means that the relative value to the incumbent of developing the idea is higher when demand is larger, which leads to the following corollary to Proposition 3:

Corollary 1. *The range of ideas that are inefficiently developed by the incumbent rather than by a spin-out is weakly larger when the magnitude of demand is larger (higher α) and when products have broader appeal and greater substitutability (lower β).*

This is because the larger is demand in either of these senses, the more that a newly introduced product will cannibalize the existing product and so the greater the incentive for the incumbent to engage in defensive action. However, this logic does *not* extend to the range of ideas that are discarded by the firm rather than developed by the researcher; the effect of greater demand parameters on this margin is ambiguous, since it is more expensive for the firm to compensate the researcher and discard the idea when demand is greater.

Figure 9 illustrates for an idea at a given distance an example of how the parameter regions for each outcome change as the demand parameters increase. For an idea at a given distance, it is more likely that there are parameter values for which inefficient development by the firm occurs, and the range of such parameter values is increasing.

From Table 3 we can also see how the magnitude of the welfare loss in the inefficient cases depends on demand parameters. In the case in which the idea is discarded rather than being developed by the researcher, the welfare loss and the reduction in consumer surplus are both larger when demand is larger, since greater benefit from the product's development is being foregone. In the case in which the idea is developed by the firm rather than the researcher, the welfare loss depends only on the foregone saving on the cost of production—the gap between the production cost for the firm and researcher—and not on demand. However, the loss in consumer surplus is again higher when demand parameters are higher.

5.2 Inefficient outcomes and the cost of fit

In this section we ask how the outcome for an idea depends on the firm's cost of fit. The lower is the cost of development for a given idea, the higher is the payoff to the incumbent when it

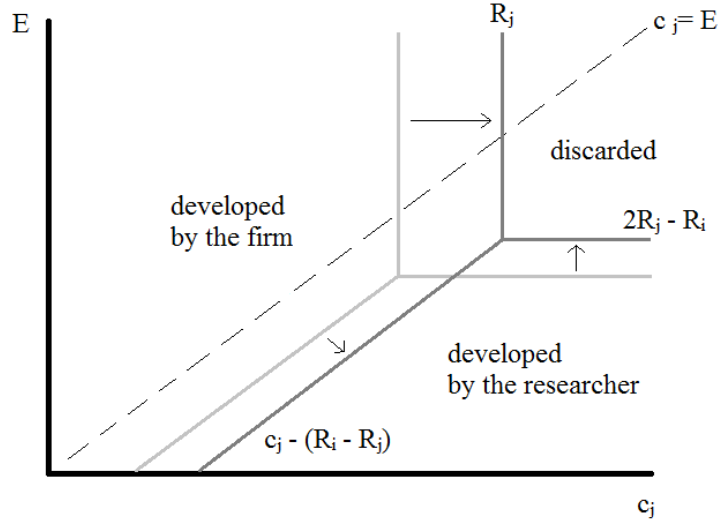


Figure 9: Greater demand (higher α or smaller β) expands inefficient regions

develops the idea. This has two effects: first, all else being equal it is more likely that the socially efficient outcome for a given idea is that it be developed by the firm; second, the firm has a greater incentive to buy and develop the idea in cases in which the socially efficient outcome is for the idea to be developed by the researcher.

The following corollary to Proposition 3 formalizes these notions:

Corollary 2. *When the incumbent's fit cost is lower (lower ϕ) and when the incumbent's fixed cost of development is lower (lower F):*

- a. *The range of ideas that are inefficiently developed by the incumbent rather than by a spin-out is weakly larger, as long as the researcher's cost of development remains below the incumbent's cost of development, and strictly larger if $E > 2c_j - R_i$.*
- b. *The range of ideas that are inefficiently discarded by the incumbent rather than developed by a spin-out is weakly smaller, and strictly smaller if $E < c_j$.*

As long as the researcher's cost to develop E remains below c_j , then the second effect applies, and reductions in c_j expand the range of idea locations such that a given idea will be developed inefficiently by the firm. However, if c_j falls below E , this type of inefficient outcome cannot be realized as the incumbent then is the lower-cost developer. It is further the case that since the

incumbent's incentive to discard an idea is everywhere decreasing as the cost of development falls, then reductions in c_j contract the range of ideas such that an idea is inefficiently discarded. Note that in the limit as c_j tends to zero there can be no inefficient outcomes.

To illustrate these effects, first consider the analog of Figure 6 for a given value of c_j : Again

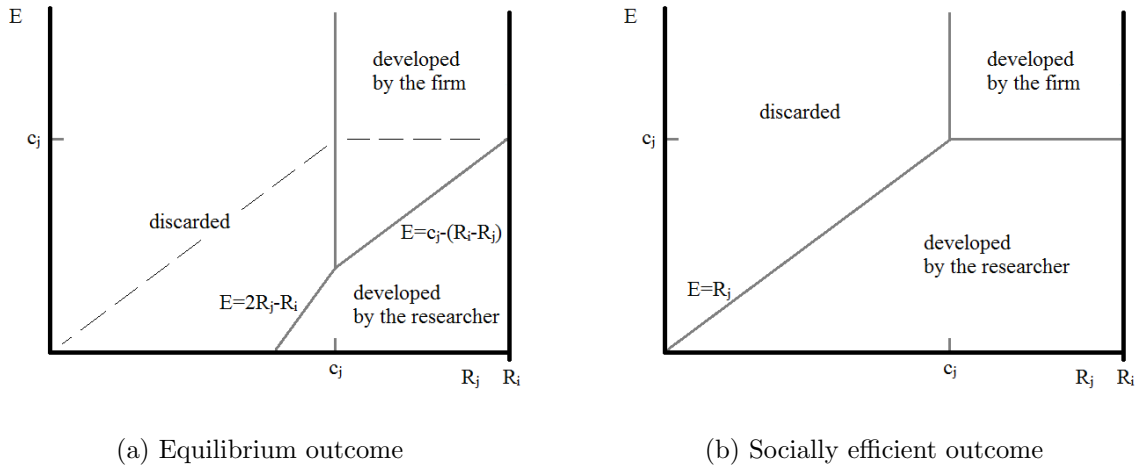


Figure 10: Equilibrium and efficient outcomes

there are regions in which the inefficient outcome is realized. Figure 11 illustrates how these regions change as c_j falls: Since the incumbent's cost of development is falling, the region in which the idea

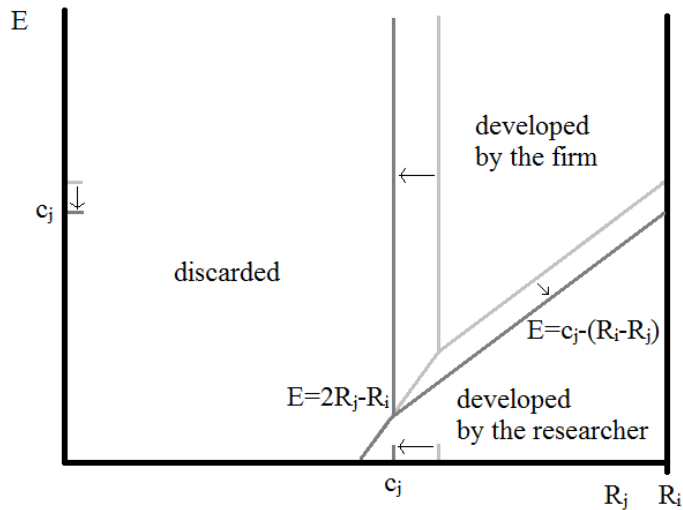


Figure 11: The effect of lower cost for incumbent (smaller ϕ or smaller F)

is efficiently developed by the incumbent expands. However, the region in which the incumbent inefficiently develops is also expanding.

6 Conclusion

Our paper addresses the issue of how firms decide whether to develop an idea into a new product to add to its portfolio. Using a spatial model of competition in which distance in product space captures the ‘fit’ cost to develop the new product and the degree of substitutability between the old product and the new (Habib et al., forthcoming), we study the firm’s choice of which new products to develop. Substitutability implies that a monopolist would not choose to develop ideas that are too close to its current portfolio, while fit costs imply that it would not choose to develop ideas that are too distant. Beyond these unilateral pressures, there can exist (unprofitable) ideas that the monopolist would prefer to develop defensively.

In this model we consider a setting in which an idea arrives to a researcher employed by an incumbent firm. We assume no contracting frictions or information asymmetries, so that the ultimate ‘ownership’ of this idea is fully negotiable and predictable. Even in this fluid setting, the competitive loss to the incumbent from a spin-out developing a substitutable product creates incentive for the incumbent to take (or retain) ownership of ideas for which the socially efficient outcome would be development by the researcher as a spin-out. These ideas are those that fall at ‘intermediate’ distance from the incumbent’s existing portfolio, and cannot be identified simply by observing which ideas are ‘shelved’; such ideas may either be shelved or developed by the incumbent.

An inefficiently used idea is then either one produced by the higher-cost producer or not produced at all when it could be profitably produced. In both cases consumers are hurt due to foregone competition between overlapping product varieties. The likelihood of such inefficient outcomes existing, the range of distances at which ideas will be inefficiently used, and the magnitude of the inefficiency are all bigger the bigger is market demand. In other words, the larger the value of the market, the more acute the social loss from inefficient use of ideas.

There are a number of avenues for future research. First, our work focuses on the impact of an innovative process that is not focused. One avenue would be to consider what happens when the

firm can choose which products to produce and the order in which it may choose to produce its products. Does it produce new products further and further away from its original product or does it backfill, producing first further away and then producing products closer to its original product? Second, our work focuses on the case where products have the same degree of substitutability. What if the new product's substitutability could in some sense be limited by the firm? A natural question in that case would be to study how that might affect the firm's decisions. Another avenue is to study the case where products are complementary and vary in their degree of complementary when the firm's resources are limited. Under what conditions would it benefit the firm to have another firm produce a complementary product to its own? This could help address the question of industry architecture and how firms may choose to affect it. Finally, our work focuses on the case where the market value of each product is the same. One may ask how differences in product values affect the analysis.

Our results have important implications for policy makers. There has been a recent focus on the use of sleeping patents as an anticompetitive tool for firms (Palomeras, 2003), but our work suggests that patents which are used by firms may also have anticompetitive implications. This suggests that anticompetitive authorities should be concerned identifying when firms develop products to limit the effects of competition. Our model provides a mechanism for identifying these situations by comparing the substitutability between products to determine the cost of development for the incumbent. Further, our work highlights the cases when social inefficiency are highest; when the market value of the new product or the substitutability between products is greatest. Given the recent interest in increasing entrepreneurship via policies that lower the costs of creating new firms and producing new products, our work has important implications for how effective different policies might be. Policies that focus on developing products that are less likely to be substitutes for existing products or have lower market value might be cheaper ways of increasing entry.

References

- Arrow, Kenneth J. (1962), “Economic welfare and the allocation of resources for invention.” In *The Rate and Direction of Inventive Activity: Economic and Social Factors*, 609–625, Princeton, NJ: Princeton University Press.
- Cassiman, Bruno and Masako Ueda (2006), “Optimal project rejection and new firm start-ups.” *Management Science*, 52, 262–275.
- Chandy, Rajesh K. and Gerard J. Tellis (2000), “The incumbent’s curse? incumbency, size, and radical product innovation.” *Journal of Marketing*, 64, 1–17.
- Christensen, Clayton M. (1997), *The Innovator’s Dilemma: When New Technologies Cause Great Firms to Fail*. Cambridge, MA: Harvard Business School Press.
- de Figueiredo, John M. and Brian S. Silverman (2007), “Churn, baby, churn: Strategic dynamics among dominant and fringe firms in a segmented industry.” *Management Science*, 53, 632–650.
- Gilbert, Richard J. and David M. G. Newbery (1982), “Preemptive patenting and the persistence of monopoly.” *American Economic Review*, 72, 514–526.
- Habib, Michael A., Ulrich Hege, and Pierre Mella-Barral (forthcoming), “Entrepreneurial spawning and firm characteristics.” *Management Science*.
- Palomeras, Neus (2003), “Sleeping patents: any reason to wake up?”
- Reinganum, Jennifer F. (1983), “Uncertain innovation and the persistence of monopoly.” *American Economic Review*, 73, 741–748.
- Reinganum, Jennifer F. (1984), “Practical implications of game theoretic models of r&d.” *American Economic Review*, 74, 61–66.

A Proofs

Proposition 1

Proof. $R_j = 0$ at $d = 0$, is strictly increasing and concave up to $d = \frac{2\alpha}{\beta}$, and is constant at $\frac{\alpha^2}{\beta}$ when $d \geq \frac{2\alpha}{\beta}$. At $d = 0$, $c_j = F > R_j$, and c_j is strictly increasing with $c'_j(d) = \phi \forall d$.

Thus $R_j < c_j \forall d$ if and only if $\nexists d$ such that $R_j = c_j$. $R_j = c_j$ when $d = \frac{(\alpha - \phi) \pm \sqrt{(\alpha - \phi)^2 - \beta F}}{\frac{1}{2}\beta}$, and so if $\beta F > (\alpha - \phi)^2$ then $\nexists d$ such that $R_j = c_j$. Then $R_j < c_j \forall d$ and so no innovation will be developed at any distance.

If $\beta F = (\alpha - \phi)^2$ then $R_j = c_j$ when $d = \frac{\alpha - \phi}{\frac{1}{2}\beta}$ and so the firm will develop if $d = \frac{\alpha - \phi}{\frac{1}{2}\beta}$.

If $\beta F < (\alpha - \phi)^2$ then $R_j \geq c_j$ when $d \in [\underline{d}, \bar{d}]$, where $\underline{d} \equiv \frac{(\alpha - \phi) - \sqrt{(\alpha - \phi)^2 - \beta F}}{\frac{1}{2}\beta}$ and $\bar{d} \equiv \frac{(\alpha - \phi) + \sqrt{(\alpha - \phi)^2 - \beta F}}{\frac{1}{2}\beta}$ if $\frac{(\alpha - \phi) + \sqrt{(\alpha - \phi)^2 - \beta F}}{\frac{1}{2}\beta} < \frac{2\alpha}{\beta}$ and $\bar{d} \equiv \frac{1}{\phi}(\frac{\alpha^2}{\beta} - F)$ otherwise. Since $R_j \geq c_j$ when $d \in [\underline{d}, \bar{d}]$ the firm will develop if $d_{ij} \in [\underline{d}, \bar{d}]$.

$\underline{d}'(F) > 0$, $\underline{d}'(\phi) > 0$, $\underline{d}'(\beta) > 0$ and $\underline{d}'(\alpha) < 0$; $\bar{d}'(F) < 0$, $\bar{d}'(\phi) < 0$, $\bar{d}'(\beta) < 0$ and $\bar{d}'(\alpha) > 0$.

This completes the proof. \square

Proposition 2

At stage 3, if the entrant chooses to develop y_j it will earn $-E$ if the incumbent developed in stage 2 and $R_j - E$ if the incumbent did not develop in stage 2. The entrant will thus develop if and only if the incumbent did not develop and $R_j > E$.

By backward induction, at round 2 the incumbent therefore earns $R_j - c_j$ by developing y_j . If it chooses not to develop x_j , it earns 0 if $R_j < E$ and $(R_j - R_i)$ if $R_j - E > 0$, since in the latter case the entrant will enter and compete away some of the incumbent's existing surplus.

If $R_j > c_j$, the incumbent will thus either earn $R_j - c_j$ by developing y_j and earn at most zero by not developing. Therefore if $R_j - c_j > 0$, the incumbent will choose to develop at stage 2.

If $R_j > E$, the incumbent will either earn $R_j - c_j$ by developing y_j and lose $(R_j - R_i)$ by not developing, and so will choose to develop if and only if $R_j - c_j > R_j - R_i$; that is, if $R_i > c_j$. Since $d_{ij} > d_E^0$ only when $R_j > E$, the incumbent will thus choose to develop at stage 2 when $d_{ij} > d_E^0$ and $R_i > c_j$.

If neither $R_j > c_j$, $d_{ij} > d_E^0$ and $R_i > c_j$, then the incumbent earns zero by not developing and

less than zero by developing. Thus the incumbent develops y_j only if $R_j > c_j$, or $d_{ij} > d_E^0$ and $R_i > c_j$.

Proposition 3

In stage 4b), S will develop if and only if $R_j > E$. In stage 4a), M will develop if and only if $R_j > c_j$.

In stage 3, S earns $\max\{R_j - E, 0\}$ by rejecting p and earns p by accepting. S thus rejects in stage 3 if and only if $p < \max\{R_j - E, 0\}$.

First consider the case in which $\max\{R_j - E, 0\} = 0$. Then in stage 2 M earns $-p$ by offering $p > 0$, since then S will accept and choose not to develop. If M offers $p = 0$, S will accept in stage 3 and so M will have the idea and earn $\max\{R_j - c_j, 0\}$. Since $\max\{R_j - c_j, 0\} \geq 0$, M will offer $p = 0$, buy the idea, and develop the idea if and only if $R_j > c_j$. Thus if $c_j < R_j$ and $E > R_j$ the idea will be developed by M (case 2a.) and if $c_j > R_j$ and $E > R_j$ the idea will be discarded (case 3a.).

Next consider the case in which $\max\{R_j - E, 0\} = R_j - E$. If M offers $p < R_j - E$ then S will reject and choose to develop the idea. In this case M earns $-(R_i - R_j)$ due to the competitive loss. If M offers $p \geq R_j - E$ then R will accept. M will then earn $-p + \max\{R_j - c_j, 0\}$; since in this case $p = R_j - E$ strictly dominates any $p > R_j - E$ we can restrict attention to $p = R_j - E$. M will thus offer $p = R_j - E$ if and only if $-(R_j - E) + \max\{R_j - c_j, 0\} > -(R_i - R_j)$.

Of these consider first the case in which $\max\{R_j - c_j, 0\} = 0$. Then M earns $-(R_j - E)$ by offering $p = R_j - E$ and earns $-(R_i - R_j)$ by offering a smaller p . Thus if $R_j > E$, $R_j < c_j$ and $-(R_j - E) > -(R_i - R_j)$, then M buys the idea and discards it (case 3b.). If $R_j > E$, $R_j < c_j$ and $-(R_j - E) < -(R_i - R_j)$, then M offers p smaller than $R_j - E$; the researcher rejects and develops (case 1a.).

Next consider $\max\{R_j - c_j, 0\} = R_j - c_j$. In this case M will develop the idea if it buys it and so earns $-(R_j - E) + (R_j - c_j) = E - c_j$ by offering $p = R_j - E$. Again M earns $-(R_i - R_j)$ by offering a smaller p since then S will not accept. Thus if $R_j > E$, $R_j > c_j$ and $E - c_j > -(R_i - R_j)$, then M buys the idea and develops it (case 2b.). If $R_j > E$, $R_j < c_j$ and $E - c_j < -(R_i - R_j)$, then M offers p smaller than $R_j - E$; the researcher rejects and develops (case 1b.).