The Blessing of Targeted Innovations in a Competitive Market

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Abstract

Innovation is a key component of competitive strategy but a firm must introduce as well as create innovations to gain advantage. These introductions are anything but simple. Rapid advances in technology and product evolution can result in innovations not being fully understood by consumers. As a result, choosing the optimal level of product innovation in competitive markets is challenging. To examine this question, we study a firm's decision in terms of both the nature of innovation and pricing when it enters a market where an incumbent provides a basic product with technology that everyone understands. In a market with two consumers, an entrant chooses between introducing a new product that represents a) a drastic innovation targeted to one consumer or b) a general improvement of smaller magnitude that both consumers value. Drastic innovation implies advanced functions over the basic product but these new features may not be appreciated by all consumers. This implies that the willingness to pay for an innovation classifed as drastic is often heterogeneous. Our analysis shows that, when an entrant introduces a drastically innovative product that is perceived heterogeneously, price competition with the incumbent entails mixed-strategy equilibrium where the entrant maximizes profit from the consumer who pays extra for the new features. In contrast, an entrant with a new product classfied as a general improvement sets price to capture business from both consumers. Here, sales for the incumbent's basic product tail off. The ability to substantially reduce the incumbent's sales suggests that general improvements should be globally preferred to drastic innovations with narrower appeal. This reasoning is flawed because product innovations have indirect effects on market competition. In particular, to create equivalent profit for an entrant, a general improvement needs to create significantly more value in the market than a drastic innovation for a sub-segment. The reason is that a locally drastic innovation relaxes price competition with the incumbent. This finding has managerial implications for firms that use new product development and pricing to compete for consumers who are heterogeneous in their appreciation of new technology.

Keywords: product development, targeting, mixed pricing strategies, drastic innovations.

1 Introduction

1.1 Background

Innovation is a critical element of competitive strategy and to gain advantage a firm must both develop and introduce products utilizing new technology. However, rapid advances in technology lead to some innovations not being fully understood or appreciated by the market.[1] As a result, choosing the optimal level of product innovation is challenging. Not only is innovation costly and risky but there is no guarantee that the market will fully appreciate the value of an innovative product. We are interested in learning more about how firms should manage the innovation process in terms of a) developing and introducing new technology and b) understanding how these innovations should be priced when they are launched.

To study this topic, we examine the decisions a firm takes to develop and then price an innovation when it enters a market with an incumbent that provides a basic product with technology that is understood by the market. In a representative market with two consumers, an entrant chooses between introducing a new product that represents a) a drastic innovation targeted for one consumer or b) a general improvement of smaller magnitude that both consumers value. The idea is that a drastic innovation often entails providing new or highly advanced functions versus the basic product. Since some but not all consumers find the new features valuable, the willingness to pay for drastically innovative products is often heterogeneous.

To illustrate the contrast between drastic innovation and general improvements, consider the following example that comes from the diaper pail category. Diaper pails are popular for families that use disposable diapers for new born babies. A "basic" product within this category is any trash-can like container that can be lined with a plastic bag for disposal. Figure 1 illustrates a basic product, priced at $29.25 on the Home Depot website. A Dekor Plus diaper pail in Figure 2 features a lid to isolate the smell of used diapers plus a one-step pedal to open the pail and enable one-hand diaper disposal. This Dekor Plus pail, priced at $39.99 on the mbean.com (MagicBeans) website can then be considered an innovative product which provides a "general improvement" over the basic pail of Figure 1. The reason we describe Dekor Plus as a general improvement is that almost all users appreciate the benefits of smell-isolation and the convenience of one-step opening. Finally, the Graco diaper pail in Figure 3 features specially-designed filters to trap diaper odors. Moreover, the product incorporates a motion-sensor lid which allows complete hands-free

[1] One recent example could be the lukewarm consumer responses to Windows 8 which introduces a radically new user interface involving use of a touch screeen in addition to a keyboard and mouse (Wong 2013).

Figure 1: Carlisle Trimline Polyethylene Can

Figure 2: Dekor Plus Diaper Pail

Figure 3: Graco Sensored Diaper Pail

opening. In comparison with the products of Figures 1 and 2, the sensor-motioned diaper pail is an example of "drastically innovative" product. Unsurprisingly, the retail price for the Graco pail is $79.95. Unsurprisingly, this price prevents some families from considering the Graco diaper pail. Interestingly, the co-existence of both positive and negative customer reviews on Amazon (as shown in Figure 4 below) further underlines heterogeneous consumer acceptance of the sensor motion technology of the Graco pail.

Another example of a drastic innovation that appeals to some but not all consumers comes from the world of privately owned sailboats. For people who wanted to sail alone (or without crew), self tailing winches were a drastic innovation introduced in the 1960s. With standard winches (as in Figure 5), two people were needed to haul in a sail in anything but the lightest of winds: one person was required to turn the handle on the winch (to grind) and a second person was needed to pull in the rope (to tail).

Self-tailing winches meant that this process could be handled efficiently by one person (please see Figure 6). Similar to the Graco Diaper Pail, the self-tailing feature was not attractive to all boat owners. In particular, for boat owners who raced their boats with big crews, the innovation was unappealing. The key objective when racing is to bring in a sail quickly. With a big crew there are people to do the tailing and the sail can be sheeted in more quickly without the tailing mechanism.[2]

In the next subsection, we move to a discussion of the related literature.

[2] Innovation in winch design since the 1960s has improved the speed at which self tailing winches can be operated.

Figure 4: Amazon Customer Review for Graco Sensored Diaper Pail

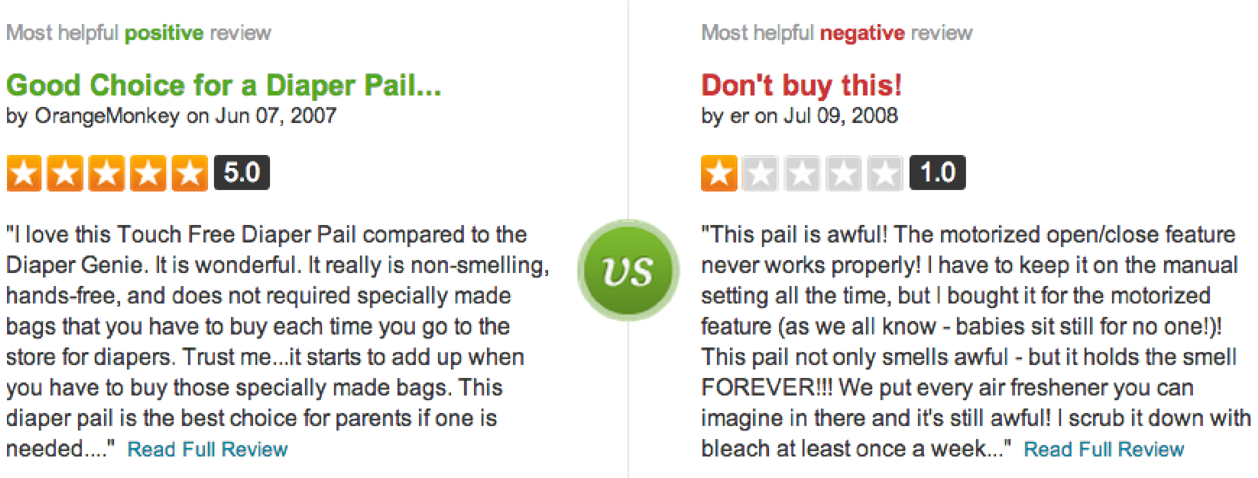

Figure 5: Standard Winch

Figure 6: Self Tailing Winch

1.2 Related Literature

This paper stands at the intersection of three streams of marketing literature. Substantively it is related to the literature on product innovation and the targeting of the marketing mix, while the methodology builds on the literature that uses mixed-strategy equilibria to characterize price competition when pure strategy equilibria do not exist.

There has been a large body of research on product innovation (for a detailed review see Hauser, Tellis and Griffin 2006). Our analysis combines demand-side consumer heterogeneity and supply-side product development to examine how choice about the magnitude of an innovation influences a firm's entry and pricing strategies. On the demand side, consumers are known to respond heterogeneously to innovation (e.g. Hirschman 1980). To facilitate our analysis, we model attitudes towards a drastically innovative product in discrete terms (Farrell and Saloner 1985). To be specific, one segment of consumers is assumed to appreciate the drastically innovative product (and is willing to pay more for it) independent of other users' behavior. In contrast, the second consumer segment is indifferent towards the innovation and is not willing to pay extra beyond the basic product price for the drastically innovative product. On the supply side, we are studying a firm's decision about the level of product innovation to choose (Garcia and Calantone 2002). In particular, we examine an innovative firm's decision to enter a market with a product that provides a general improvement over the existing product (e.g. sequential generation as in Weitzman et al. 1981; Padmanabhan et al. 1997; incremental innovation as in Griffin 1997) or with a drastically innovative product (e.g. products with an entirely new set of performance features as in Leifer et al. 2000). Compared to general product improvement, drastic product innovation is associated with greater risks, a frequently-identified one being consumer acceptance and marketing (e.g. Keizer and Halman 2007). Chandy and Tellis (1998), Chandy et al. (2003) identify several drivers of a firm introducing a radical product innovation which includes the impact of cannibalization and the fear of obsolescence. Despite being appreciated by only part of the market, we find that under general conditions introducing a drastically innovative product is a more desirable as it can relax as opposed to exacerbate the price competition with an incumbent. Higher profitability of drastic innovations is consistent with the empirical findings of Chandy and Tellis (2000) who find that new entrants are more likely to introduce radical innovations than are incumbents.

An important feature of our model is that the entrant has the choice of developing products with different levels of innovativeness. We explicitly examine the decision to develop a drastically innovative product or a general improvement to compete with the incumbent's basic product. In addition, our model allows the entrant to optimize the level of innovativeness for each type of innovation.

A number of academic papers suggest that mixed pricing strategies are a reflection of markets characterized by price promotion (e.g. Varian 1980; Narasimhan 1988; Raju, Srinivasan and Lal 1990; Rao 1991). These studies are motivated in a context where competing firms sell a single product to satisfy the demand of a heterogeneous consumer base. Each firm has a loyal customer segment and they compete for a price-sensitive switching segment (Narasimhan 1988). We study price competition between an incumbent offering a basic product and an entrant offering an innovative product. A priori there is no loyal segment for either firm in our model; however, drastically innovative produces are assumed to enjoy higher willingness to pay (WTP) for a segment of the market. In this situation, competition leads to mixed pricing strategies where the entrant only serves the consumer segment willing to pay more for the innovative product. In contrast, the incumbent sells to consumers who do not value the innovation and sometimes offers sufficient discounts to attract consumers that value the drastic innovation. In other words, the entrant cleanly segments the market through the introduction of a drastically innovative product that competes with the incumbent's basic product.

Finally our research is related to studies of targeting marketing mix components towards specific groups of consumers in the market (e.g. Iyer and Soberman 2000; Chen, Narasimhan and Zhang 2001; Iyer, Soberman and Villas-Boas 2005). In our model, a generally improved product can be considered a uniform offer to the market upon the entry of the innovative firm. Conversely, a drastically innovative product is an offer targeted to a consumer segment that appreciates the drastic innovation and is willing to pay more for it. Our study characterizes the conditions under which targeting part of the consumer market with a drastically innovative product is more desirable than uniformly serving the market with a generally improved product. The trade-off between the entire market and a targeted segment is shown to be affected by the indirect effects of targeting on price competition.

1.3 Summary of Key Findings

Our analysis indicates that an entrant with a "targeted" drastically innovative product only sells to the consumer segment that is willing to pay more for the innovation. In contrast, an entrant with a new product that represents a general improvement prices low enough to capture business from the entire market. The analysis shows that drastic innovations which create equivalent value in the market to a candidate general improvement are preferred to the general improvement because of the nature of price competition that results after launch.

The model highlights the indirect effects of the product introduction on market competition. Said differently, to create the same level of profits for an entrant, the analysis shows that a product associated with a general improvement needs to create more value in the market than a product associated with a drastic innovation for a sub-segment. The reason is that price competition in the presence of a drastically innovative product leads to segmentation and this relaxes competition with the incumbent. This is not the case for a *small* general improvement. These findings provide useful managerial implications regarding how firms should manage new product development and pricing when consumers are heterogeneous in the acceptance of new technology.

2 Model Setup

On the supply side, we assume that two firms offer products in the same category. Firm 1 offers a basic product, while Firm 2 offers an improved product compared to the basic product of Firm 1. Without loss of generality, we normalize Firm 1's cost of producing the basic product to zero and assume that Firm 2 incurs a marginal cost of c to produce the improved product. In terms of the product innovation type, Firm 2 has two options. One is to offer a product that represents a "drastic" innovation, while the other is to offer a product with a "general" improvement. Linking our nomenclature to the typology established in the literature, the "drastic" innovation in our model would include radical, really new, or discontinuous innovations as summarized in Garcia and Calantone (2002). Conversely, the "general improvement" in our model is analogous to incremental innovations (Song and Montoya-Weiss 1998).

On the demand side, we assume there are two consumers, namely Mr. Jones and Mr. Brown (the total size of the market is assumed to be 2). Both consumers have the same maximum willingness to pay, $V > 0$, for Firm 1's basic product. If Firm 2's product provides a general improvement compared to the basic product, both consumers are willing to pay a maximum $V + g$ for Firm 2's product. If instead, Firm 2's product provides a drastic innovation, only Mr. Brown appreciates its superior features and is willing to pay a maximum $V + d$ for Firm 2's product. Mr. Jones either cannot distinguish between a basic product and a drastically innovative one, or is not willing to pay extra for the innovation. As a result, he remains willing to pay a maximum of V for Firm 2's drastically innovative product.

We assume $d > V$ and $g < V$ to reflect the characteristics of a drastically innovative product and a generally improved product, respectively.[3] The basis for $d > V$ is to emphasize that the drastic innovation is preferred by Mr. Brown even when Firm 1 charges a price of 0, Firm 2 can charge any price less than $d - V$ and still sell to Mr. Brown.

It is important to note that Mr. Brown is not a "loyal" consumer of Firm 2 (the entrant) in the sense of a standard Varian model. Instead, Mr. Brown and Mr. Jones are both "switchers" where the monetary values needed to induce switching are different (Narasimhan 1988). Consumers purchase from the firm whose product price gives them the highest surplus. We further assume that at equal utility levels, consumers choose randomly between the two firms.

Finally, we assume that the cost of innovation is a convex function of the value created. Hence for Firm 2 to develop a drastic innovation where Mr. Brown is willing to pay d beyond his valuation for the basic product, it will cost Firm 2 $\frac{\gamma}{2}(1d)^2$,where $\gamma > 0$. The number 1 inside parentheses indicates that only one consumer (Mr. Brown) is willing to pay incrementally for the drastically innovative product. Similarly, Firm 2's cost of innovation for a general product improvement can be written as $\frac{\gamma}{2}(2g)^2$ as both consumers in the market are willing to pay an increment of g for the general improvement. We focus our study on the intermediate case for the innovation cost where $\frac{1}{2} < \gamma V < 1$. This constraint ensures a) the viability of developing both drastic and general improvements and b) that the optimal level of improvement lies in the prescribed zones.

[3] Using the "Diaper Pail" example (Figures 1-3) at the Introduction section, we would have $V = 29.25, g = (39.99 - 29.25) = 10.74$, and $d = (79.95 - 29.25) = 50.7$.

We model a two-stage market entry game. At the first stage, Firm 2 decides on the innovation strategy used to enter market and compete with the basic product offered by Firm 1. In this stage, Firm 2's decision has two aspects: the choice between "drastic innovation" and "general improvement" and the optimal level of innovativeness within each option. In the second stage, Firm 1 and 2 simultaneously set prices of their products to compete for demand from Mr. Brown and Mr. Jones. After observing the product and price information from both firms, the consumers make purchase decisions, and profits are realized for both firms. We use backward induction to solve for the Subgame-Perfect Nash equilibrium. In the following section, we first identify the Nash Equilibrium in pricing between the two firms, conditonal upon Firm 2's choice of "drastic innovation" or "general improvement". Returning to the first stage, Firm 2's equilibrium innovation strategy is determined as a function of the corresponding price competition that results in the second stage.

3 Main Model Analysis

For tractability, we assume that $c = 0$ (this is an assumption that we relax later). This implies that there is no additional cost to produce the innovative product. In the following subsections, we first derive the price equilibrium when Firm 2 enters with a drastically innovative product. Second, we discuss the price equilibrium if Firm 2 enters with a generally improved product. Finally we compare Firm 2's payoffs between the two options to identify the optimal entry strategy in terms of product innovation.

3.1 Competition using Drastically Innovative Product

The following proposition describes the equilibrium pricing strategies of the two firms when Firm 2 offers a product with a drastic innovation for which only one of the two customers (Mr. Brown) is willing to pay a premium d over the base product offered by Firm 1.

Proposition 1 *When Firm 2 enters with a drastic innovation, the equilibrium involves Firm 1 choosing a mixed strategy in prices over the interval* $\left(\frac{V}{2}, V\right)$ *with expected profit of* $\pi_1 = V$. *The cumulative distribution function (CDF) for Firm 1's prices is:*

$$F_1(p_1) = \begin{cases} 0 & if \quad p_1 < \frac{V}{2} \\ 1 - \frac{V+2d}{2(p_1+d)} & if \quad p_1 \in (\frac{V}{2}, V) \\ 1 & if \quad p_1 \geq V \end{cases}$$

Firm 2 chooses a mixed strategy in prices over the interval $\left(\frac{V}{2}+d, V+d\right)$ *with expected profit of* $\pi_2 = \frac{V}{2}+d$. *The cumulative distribution function (CDF) for Firm 2's prices is:*

$$F_2(p_2) = \begin{cases} 0 & \text{if} \quad p_2 < \frac{V}{2}+d \\ 2 - \frac{V}{p_2-d} & \text{if} \quad p_2 \in (\frac{V}{2}+d, V+d) \\ 1 & \text{if} \quad p_2 \geq V+d \end{cases}$$

Proof. see Appendix. ■

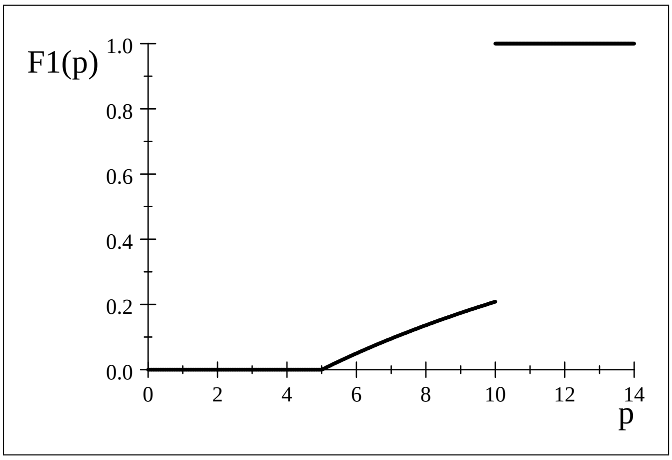

Figure 7a: CDF1 ($V = 10, d = 14$)

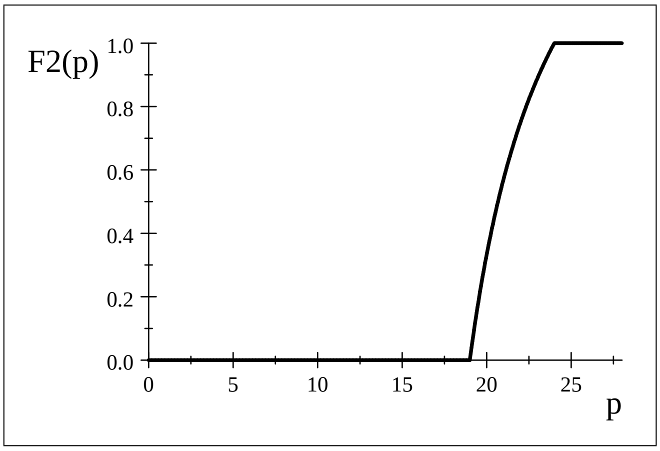

Figure 7b: CDF2 ($V = 10, d = 14$)

Figure 7(a-b) illustrate the equilibrium CDFs for the pricing of the two firms reported in Proposition 1. While the equilibrium CDF of Firm 2 is continuous, the equilibrium CDF of Firm 1 (the provider of the basic product), has a mass point at $p_1 = V$ (Figure 7a) with a probability of $\frac{V+2d}{2(V+d)}$. This means that the cumulative probability of being in the lower part of the distribution is $\frac{V}{2(V+d)}$.

As a result, the likelihood of there being a jump in the equilibrium price distribution of Firm 1 is *1* since $\frac{V}{2(V+d)} \in (0,1)$.

Proposition 1 implies that for Firm 2 (the firm with a drastically innovative product), demand is sourced entirely from the consumer that understands (and is willing to pay for) the innovation, i.e., Mr. Brown. But Mr. Brown is sometimes tempted to buy the basic product due to its low price. Conversely, Firm 1 always serves the consumer that sees no value in Firm 2's innovation, i.e., Mr. Jones. Firm 1 also captures demand occasionally from Mr. Brown and this occurs when its price advantage over Firm 2 exceeds the benefit d associated with Firm 2's product. The reason that Firm 2 has an incentive to raise price is to capture part of the surplus V (the base benefit associated with the category) as well as the benefit d associated with the innovation. Of course, when Firm 2 does this, it becomes vulnerable to aggressive pricing by Firm 1. Because the mixed strategy equilibrium can be interpreted as a situation where the firms compete with price promotions, this provides a perspective for introductory promotions that are used to launch new and innovative products (Raju et al 1990). Conversely, it also explains why incumbents may defend their turf just as fiercely with price promotions of their own.

When a new entrant makes a decision about the type of innovation, the entrant anticipates the price competition that will take place afterwards. The following Lemma reports Firm 2's optimal level of drastic innovation when anticipating price competition with Firm 1 upon entry.

Lemma 1 *When anticipating the price competition with Firm 1 (provider of basic product where both consumers are willing to pay maximum V), Firm 2 chooses the optimal level of drastic innovation to be $d^* = \frac{1}{\gamma}$. The net profit of Firm 2 under drastic innovation is $\pi_2^* = \frac{\gamma V+1}{2\gamma}$.*

Proof. see Appendix. ■

As indicated in Proposition 1, when the entrant offers a drastic innovation, it sells to at most a single consumer (Mr. Brown) for an expected profit $\frac{V}{2} + d$ which is linearly increasing in the level of the innovation (d). However, the cost of creating a drastic innovation is convex. Hence there is an optimal level of innovation that maximizes profit for the entrant. As indicated in Lemma 1, the optimal level of drastic innovation (d^*) is inversely related to the marginal innovation cost parameter (γ). That is, a more efficient innovation process (a smaller γ) leads to innovations of higher magnitude. The next subsection discusses the entrant's optimal innovation level for a generally-improved product. Comparison of the results of Sections 3.1 and 3.2 leads to the optimal type of innovation with which Firm 2 enters the market.

3.2 Competition using Generally Improved Product

Instead of a drastic innovation appreciated by part of the market, Firm 2 has a second option: to develop an innovative product which delivers an improvement of smaller magnitude that is valued by both consumers. As noted earlier, we assume that both consumers in the market are willing to pay a maximum of $V + g$ $(g < V)$ for Firm 2's product when it delivers a general improvement compared to Firm 1's basic product. Under the "general improvement" option, Firm 2 maximizes profit by pricing marginally less than g and capturing business from both consumers. Firm 2's problem now is to choose an optimal level of general product improvement (g) to maximize the net profit , $2g - \frac{\gamma}{2}(2g)^2$. A derivation similar to Lemma 1 yields $g^* = \frac{1}{2\gamma}$. The net profit of Firm 2 under a general improvement is $\pi_2^{**} = \frac{1}{2\gamma}$.

3.3 The Blessing of Targeted Drastic Innovation

The ability to eliminate the incumbent's sales suggests that general product improvements should be preferred to drastic innovations that only appeal to part of the market. The intuition is however, incorrect. Proposition 2 shows that drastic innovations are preferable for Firm 2 in the allowable range of innovation costs specified in Section 2.

Proposition 2 *The equilibium innovatoin strategy for Firm 2 is to enter the market with a drastically innovative product at a level of $d^* = \frac{1}{\gamma}$ and set price following the equilibrium mixed-strategy specified in Proposition 1 to compete with the incubment.*

Proof. follows directly from $\pi_2^* - \pi_2^{**} = \frac{\gamma V+1}{2\gamma} - \frac{1}{2\gamma} > 0$. **Q.E.D.** ■

Under the "general improvement" option, Firm 2 sets a price of g to sell to both Mr. Jones and Mr. Brown. This is significantly less than the lower end of its equilibrium price support $\left(\frac{V}{2} + d\right)$ under "drastic innovation" (as $g < V, d > V$). As a result, targeted drastically innovative products relax price competition with the incumbent. To enjoy the same profit level upon entry with a general improvement, Firm 2 needs to create much more value in the market. The reason is that the general improvement exacerbates price competition. These findings highlight the indirect effects of the product introduction on market price competition.

4 Model Extensions

The purpose of Section 4 is to establish the robustness of the main model results through three extensions. First, we consider a situation where the innovative product is more costly to produce.

Next, we compare Firm 2's optimal innovation decisions under two alternative innovation cost functions. And finally, we examine situations where the fraction of consumers who appreciate the drastic innovation is more or less than the 50/50 split that we examine in the main model.

4.1 When the Innovative Product is more costly to produce

In this subsection, we analyze how the market equilibrium is affected when Firm 2 incurs higher marginal costs than Firm 1 to produce the innovative product. In particular, we extend the structure of the main model by assuming $0 < c < \frac{V}{2}$ for the product offered by Firm 2.[4] As shown in Proposition 3, the pricing equilibrium when Firm 2 introduces a drastically innovative product is qualitatively similar with that of the main model.

Proposition 3 *When $0 < c < \frac{V}{2}$ and Firm 2 introduces a drastically innovative product, the equilibrium involves Firm 1 choosing a mixed strategy in prices over the interval $\left(\frac{V}{2}, V\right)$ with expected profit $\pi_1 = V$. The cummulative distribution function (CDF) for Firm 1's prices is:*

$$F_1(p_1) = \begin{cases} 0 & \text{if} \quad p_1 < \frac{V}{2} \\ 1 - \frac{V+2(d-c)}{2(p_1+d-c)} & \text{if} \quad p_1 \in (\frac{V}{2}, V) \\ 1 & \text{if} \quad p_1 \geq V \end{cases}$$

Firm 2 chooses a mixed pricing strategy over the interval $\left(\frac{V}{2}+d, V+d\right)$ with expected profit $\pi_2 = \frac{V}{2}+d-c$. The cumulative distribution function (CDF) for Firm 2's prices is:

$$F_2(p_2) = \begin{cases} 0 & \text{if} \quad p_2 < \frac{V}{2}+d \\ 2 - \frac{V}{p_2-d} & \text{if} \quad p_2 \in (\frac{V}{2}+d, V+d) \\ 1 & \text{if} \quad p_2 \geq V+d \end{cases}$$

Proof. See Appendix. ■

Detailed analysis in the proof for Proposition 3 shows that the equilibrium CDF of Firm 1 has a mass point at $p_1 = V$ with probability $\frac{V+2(d-c)}{2(V-c+d)}$, which is less than the probability of this mass point when $c = 0$. This implies that when the innovative product of Firm 2 is more costly to produce, the incumbent has reduced probability of pricing at V, which leads to greater cumulative probability of being in the lower part of the distribution. Said differently, Firm 1 prices more aggressively when Firm 2 is a weaker competitor due to higher production costs. As for Firm 2,

[4] The upper limit ensures that the value created by the innovation exceeds the cost incurred to produce the innovation.

it sets price the same way as in the main model. Because Firm 2 now makes less profit on a per customer basis, it protects its profit by pricing more conservatively (i.e., lower).

It is interesting to note that consumer and firm surplus move in opposite direction when comparing the results of this extension to the main model. As shown in Proposition 3, Firm 1 enjoys the same expected profit while Firm 2's expected profit decreases due to the higher production cost. Firm 2's pricing is relatively unaffected by having a positive marginal cost but Firm 1 charges an average price which is lower compared to the price charged when $c = 0$. As a result, consumer surplus increases when $c > 0$ due to the innovation benefit and lower prices.

Interestingly, the optimal level of drastic innovation remains the same as in the main model and Firm 2 prefers drastic innovations to the alternative of small general product improvement similar to the main model (Proposition 2).

4.2 Alternative Innovation Cost Function

We assume in the main model that the cost of innovation is a convex function of value created. Under the same general setting, we explore two alternative innovation cost functions in order to have a complete understanding of how cost drives Firm 2's optimal choice of innovation type. The general idea is to account for the possibility that a different R&D process might be required to develop an innovation that is drastic compared to a general-improvement.

First we consider the possibility that there are different "sunk costs" (e.g. R&D capital, physical plant capital as in Gentzoglanis 2011) required for the two innovation options. Mathematically, this "sunk cost" is represented by a fixed component ($f > 0$) in the innovation cost function. Specifically it will cost Firm 2 $f_d + \frac{\gamma}{2}(1d)^2$ to develop a drastically innovative product, and $f_g + \frac{\gamma}{2}(2g)^2$ to develop a generally improved product. Although a greater R&D capital might be expected for a drastic product innovation, a general product improvement could also require greater investment in physical plant as the volume of sales will be higher. As a result, we choose not to assume a priori whether f_d or f_g should be larger in magnitude. Proposition 4 states that drastic innovation is preferred as long as the required additional sunk cost is not too high compared to the sunk cost associated with developing a general improvement.

Proposition 4 *Under the first alternative innovation cost function, Firm 2 is better off by offering a product of drastic innovation if $f_d < \frac{V}{2} + f_g$; otherwise, Firm 2 is better off by offering a product of general improvement.*

Proof. see Appendix ■

Proposition 4 shows that different amounts of sunk costs do affect Firm 2's decision on the type of innovation that is optimal for entry. Next we investigate the possible impact that could come from different incremental costs associated with developing different types of innovations. Here we replace the marginal innovation cost parameter γ in the main model with two type-specific parameters. In particular, it will cost Firm 2 $\frac{\gamma_d}{2}(1d)^2$ to develop a drastic innovation, while it will cost Firm 2 $\frac{\gamma_g}{2}(2g)^2$ to develop a product which is a general improvement over the base product of Firm 1 $(\gamma_d, \gamma_g > 0)$. Under this alternative innovation cost function, we relax the conceptual restriction that the optimal level of general improvement (g) be lower than the basic product valuation (V). However, we retain the assumption that (g) be strictly less in magnitude than the drastic innovation (d). Proposition 5 demonstrates that general improvements are preferred if the incremental cost of this innovation type (γ_g) lies in a range that ensures the viability of developing general product improvements while being smaller compared to incremental cost of developing drastic innovation (γ_d).

Proposition 5 *Under the second alternative innovation cost function, as long as $d > g$, Firm 2 is better off entering the market competition with incumbent Firm 1's basic product by offering a generally improved product if $\frac{\gamma_d}{2} < \gamma_g < \frac{\gamma_d}{\gamma_d V+1}$; otherwise, Firm 2 is better off by offering a drastically innovative product upon entry.*

Proof. see Appendix. ■

Propositions 4 and 5 together provide a picture regarding the impact of innovation cost on Firm 2's choice of product innovation type upon entering the market to compete with Firm 1's basic product. As a complement to the main model, we find that for genenal improvements to be the preferred form of innovative entry, supply side advantages in terms of either the fixed cost or the marginal cost of innovation are needed.

4.3 Equilibrium when the Sizes of the Segments are Unequal

We examine two scenarios in this subsection. First, we consider a situation where there are more consumers in the market that appreciate and value a drastically innovative product. In particular, we assume that the market consists of 2 Mr. Browns and only 1 Mr. Jones. As reported in Proposition 6, under this scenario, the equilibrium between Firm 2 offering a drastic innovative product and Firm 1 offering the basic product is qualitatively similar to the findings of the main model.

Proposition 6 *When there are 2 Mr. Brown and 1 Mr. Jones in the market, the equilibrium involves Firm 1 choosing a mixed strategy in prices over the interval* $\left(\frac{V}{3}, V\right)$ *with expected profit of* $\pi_1 = V$*. The cumulative distribution function (CDF) for Firm 1's prices is:*

$$F_1(p_1) = \begin{cases} 0 & \textit{if} \quad p_1 < \frac{V}{3} \\ 1 - \frac{V+3d}{3(p+d)} & \textit{if} \quad p_1 \in (\frac{V}{3}, V) \\ 1 & \textit{if} \quad p_1 \geq V \end{cases}$$

Firm 2 chooses a mixed strategy in prices over the interval $\left(\frac{V}{3} + d, V + d\right)$ *with expected profit of* $\pi_2 = 2\left(\frac{V}{3} + d\right)$*. The cumulative distribution function (CDF) for firm 2's prices is:*

$$F_2(p_2) = \begin{cases} 0 & \textit{if} \quad p_2 < \frac{V}{3} + d \\ \frac{3}{2} - \frac{V}{2(p-d)} & \textit{if} \quad p_2 \in (\frac{V}{3} + d, V + d) \\ 1 & \textit{if} \quad p_2 \geq V + d \end{cases}$$

Proof. See Appendix. ■

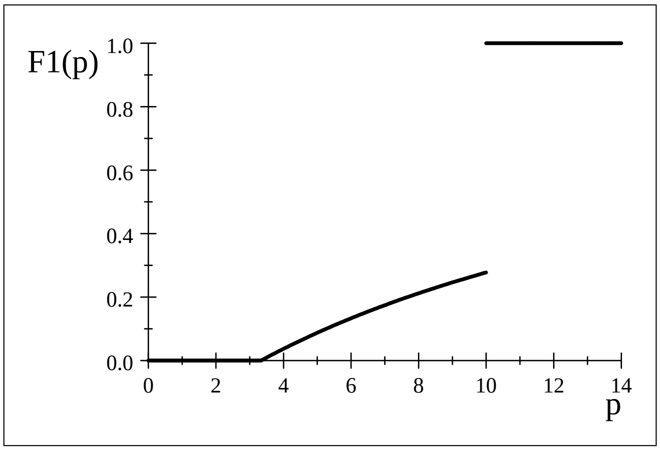

Figure 8a): CDF1 (2 Mr. Browns; $V = 10, d = 14$)

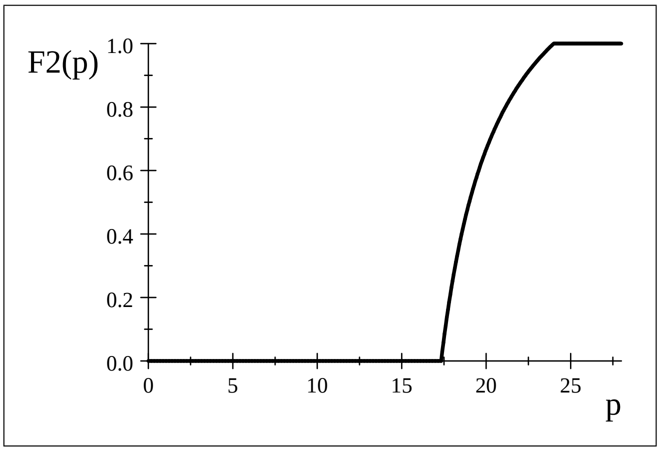

Figure 8b): CDF2 (2 Mr.Browns; $V = 10, d = 14$)

Figures 8(a-b) above illustrate the CDFs of the two firms' prices in equilibrium as reported in Proposition 5. They are of the same shape pattern as Figures 7(a-b) in the main model. Note in Figure 8(a), the equilibrium CDF of Firm 1, the provider of the basic product, has a mass point at $p_1 = V$ with probability $\frac{V+3d}{3(V+d)}$, which is smaller than that in the main model ($\frac{V+2d}{2(V+d)}$).

Because more of the market appreciates the drastically innovative product and are willing to pay for it, Firm 1 needs to be aggressive in competing with Firm 2 through price promotion. Being more aggresive in its pricing allows Firm 1 to maintain its profit of $\pi_1 = V$. Firm 2 expects greater profit ($2\left(\frac{V}{3}+d\right) > \frac{V}{2}+d$) entering a market where majority of consumers welcome the drastically innovative product. In the meantime, Firm 2 is aware that the loss will be bigger if Firm 1 takes the demand from consumers who appreciate the drastic innovation. Hence Firm 2 also lowers its price on average. The derivation of the optimal level of drastic innovation and the comparison with the option of general product improvement are analogous to the derivation for the main model. In particular, straightforward calculations show that drastic innovation strictly dominates general improvement for the range of $\frac{1}{3} < \gamma V < \frac{1}{2}$ which satisfies the condition that that $g < V < d$ and ensures the viability of developing both types of innovation.[5]

Next we consider a situation where the fraction of consumers in the market who can appreciate (and are willing to pay extra for) the drastically innovative product is less than $\frac{1}{2}$. In particular, consider a market where there is only 1 Mr. Brown but 2 Mr. Jones. We show in the appendix that Firm 2 will need a drastic innovation of much higher magnitude to create the same value as a given general improvement because the fraction of the market that values the drastic innovation is lower. Proposition 7 summaries the pricing equilibrium for Firms 1 and 2 in this situation.

Proposition 7 *When there are* 1 *Mr. Brown and* 2 *Mr. Jones in the market, with* $d > 2V$*, the pricing equilibrium involves Firm 1 choosing a mixed strategy in prices over the interval* $\left(\frac{2V}{3}, V\right)$ *with expected profit of* $\pi_1 = 2V$*. The cumulative distribution function (CDF) for firm 1's prices is:*

$$F_1(p_1) = \begin{cases} 0 & if \quad p_1 < \frac{2V}{3} \\ 1 - \frac{2V+3d}{3(p+d)} & if \quad p_1 \in (\frac{2V}{3}, V) \\ 1 & if \quad p_1 \geq V \end{cases}$$

Firm 2 chooses a mixed strategy in prices over the interval $\left(\frac{2V}{3}+d, V+d\right)$ *with expected profit of* $\pi_2 = \frac{2V}{3} + d$*. The cumulative distribution function (CDF) for firm 2's prices is:*

$$F_2(p_2) = \begin{cases} 0 & if \quad p_2 < \frac{2V}{3} + d \\ 3 - \frac{2V}{p-d} & if \quad p_2 \in (\frac{2V}{3} + d, V+d) \\ 1 & if \quad p_2 \geq V + d \end{cases}$$

[5] The allowable parameter range will be further simplied to $\gamma V < \frac{1}{2}$ if we relax the assumption of $g < V$ while only require that $g < d$.

Proof. *See Appendix.* ■

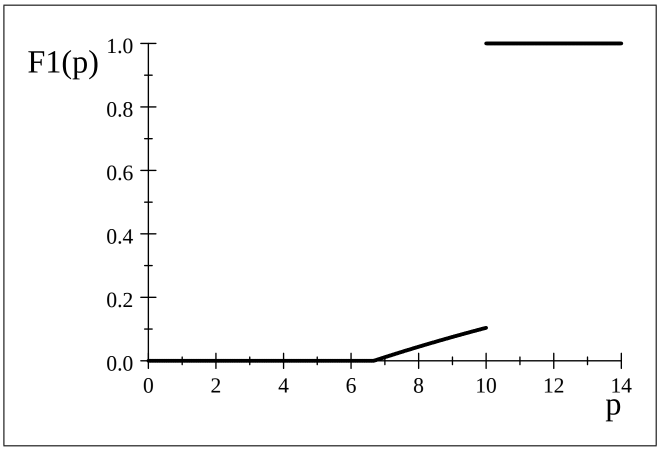

Figure 9a): CDF1 (1 Mr. Browns; $V = 10, d = 22$)

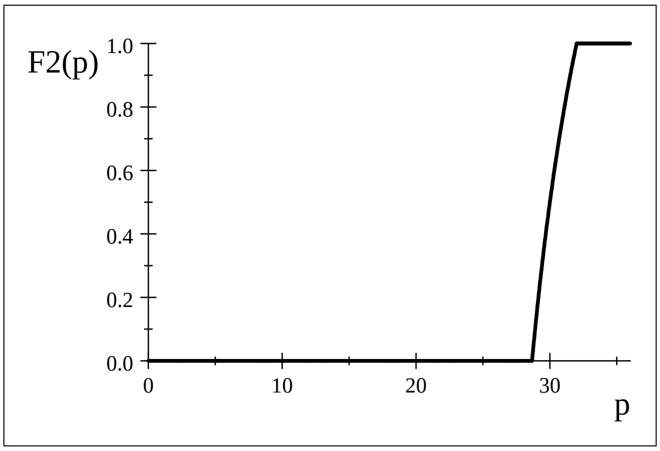

Figure 9b): CDF2 (1 Mr.Browns; $V = 10, d = 22$)

Figures 9(a-b) above illustrate the CDFs of the two firms' prices in equilibrium reported in Proposition 6. They are of the same shape pattern as Figures 7(a-b) in the main model. Here, the mass point ($p_1 = V$) in the equilibrium CDF of Firm 1 (Figure 9a) has probability $\frac{2V+3d}{3(V+d)}$, which is greater than that in the main model. This implies that because the majority of the market does not appreciate the drastically innovative product of Firm 2; Firm 1, with its offer of a basic product, is in a comparatively stronger position compared to the main model. As a result, Firm 1 is less likely to run price promotions. That is, Firm 1 always captures $\frac{2}{3}$ of the market whereas only $\frac{1}{2}$ is guaranteed in the base model. Firm 2's expected profit is lower ($\frac{2V}{3} + d < 2\left(\frac{V}{3} + d\right)$) than in the previous extension as would be expected when the target for the drastic innovation is relatively smaller. However, Firm 2's profit is higher than its profit in the base model ($\frac{2V}{3} + d > \frac{V}{2} + d$) because it benefits from Firm 1's higher prices. The optimal level of innovation under each option (drastic versus general improvement) is derived in the Appendix. Under the modified range of intermediate innovation cost ($\frac{1}{3} < \gamma V < \frac{1}{2}$), the highly drastic innovation ($d > 2V$) is still the preferred entry strategy for Firm 2.

When a firm faces the choice of developing a general improvement or drastic improvement, a key consideration is the breadth of expected appeal for the drastic innovation. Certainly the competition-reducing character of drastic innovations is a consideration. Nevertheless, the narrower the target for the drastic innovation, the higher is the required magnitude for a firm to choose the drastic innovation over the general improvement.

5 Conclusion

This paper studies a firm's decision in terms of both the nature of product innovation and pricing when entering a market where an incumbent provides a basic product with technology that consumers fully understand. When the entrant introduces a drastically innovative product that is perceived heterogeneously by consumers in the market, price competition with the incumbent leads to a mixed strategy equilibrium where the entrant only sells to the consumers who are willing to pay extra for the drastically innovative product. We present conditions under which drastic innovation is more desirable compared to entry with a general improvement. This result is driven by the indirect effects of the product introduction on market competition. Although the entrant with a general improvement can price to capture demand from the entire market, competition with the incumbent is intense and erodes much of the potential profit of the entrant. In contrast, the locally drastic innovative product effectively segments the market and relaxes the price competition with the incumbent resulting in higher profits for the entrant. Our paper thus provides important managerial recommendations on how firms should utilize new product development and pricing to compete for consumers who are heterogeneous in the acceptance of new technology.

Our model findings mean that assessing the appeal of entry into an existing market for an innovative second mover is relatively complex. To assess the potential profitability of a new innovation, the second-mover needs to account for the nature of price competition that occurs post-launch, the breadth of appeal of the innovation and the costs (both development and marginal costs) that innovation entails. Similar to the "Defender model" proposed by Hauser and Shugan (1983), we assume that the incumbent firm is passive in terms of the quality level of its existing product; however, even an incumbent with unchanged product performance will adjust its price to defend against the attack by a new competitor. Consistent with the finding in Hauser and Shugan (1983), we find that an incumbent cannot be better off after the innovative product enters the market of fixed size. This underlines the limits of defensive pricing strategy (p.333, Hauser and Shugan 1983). We contribute to the studies of defensive marketing strategy by creating a parsimonious representation of how the defender (the incumbent firm) perceives "the competitor's angle of attack to his position and the distribution of consumer tastes" to determine an optimal pricing response (p. 353, Hauser and Shugan 1983). Despite a seemingly overwhelming technology advantage, an incumbent facing entry by a drastically innovative product is able to defend part of its pre-entry profit by implementing optimal defensive pricing, that is the mixed strategies specified in Proposition 1. Because a drastically innovative product results in highly segmented consumer tastes, the incumbent can secure profit from consumer segments that do not appreciate the innovation, while occasionally using price promotions to steal demand from consumer segments where the drastically innovative product is appreciated. In contrast, an incumbent loses all of its profit when the entry represents a small improvment on the basic product for all consumers.

Several potential extensions follow naturally from our analysis. The consumer market we present is stylized and can be extended to capture consumer heterogeneity in a more complete sense by modelling a fully continuous consumer base or by including several consumer segments with different valuations for the innovation. On the firm side, one might allow for innovations specifically targeted at certain market segments or more general innovations that are coupled with targeted prices and discounts.

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Appendix

Proof for Proposition 1

We proceed in three steps. First we derive the two firms' best response functions. Next we define a "reduced" pricing game after sequentially eliminating dominated strategies of each firm (starting with stronger Firm 2). As a result, the strategies of the two firms in the "reduced" pricing game consist of only their respectively non dominated strategies. Finally the equilibrium of the reduced game is constructed by using the condition that expected profits must be equal from all strategies which are being played with positive probability.

Step 1: Deriving best response functions for the two firms

Mr. Jones has utility of $V - p_1$ from buying Firm 1's product; $V - p_2$ from buying Firm 2's product. Mr. Brown has utility of $V - p_1$ from buying Firm 1's product; $V + d - p_2$ from buying Firm 2's product. Given Firm 1's price p_1, Firm 2's best response can be summarized as:

$$BR_2(p_1) = \begin{cases} p_2 = p_1 + d & \text{if} \quad p_1 \leq V \\ p_2 = V + d & \text{if} \quad p_1 > V \end{cases}$$

Given Firm 2's price p_2, Firm 1's best response can be summarized as:

$$BR_1(p_2) = \begin{cases} p_1 = p_2 & \text{if} \quad p_2 \leq V \\ p_1 = V & \text{if} \quad V < p_2 \leq \frac{V}{2} + d \\ p_1 = p_2 - d & \text{if} \quad \frac{V}{2} + d < p_2 \leq V + d \\ p_1 = V & \text{if} \quad p_2 > V + d \end{cases}$$

Figures 10(a-b) below illustrates the two best response curves identified above using numerical values $V = 10, d = 14$.

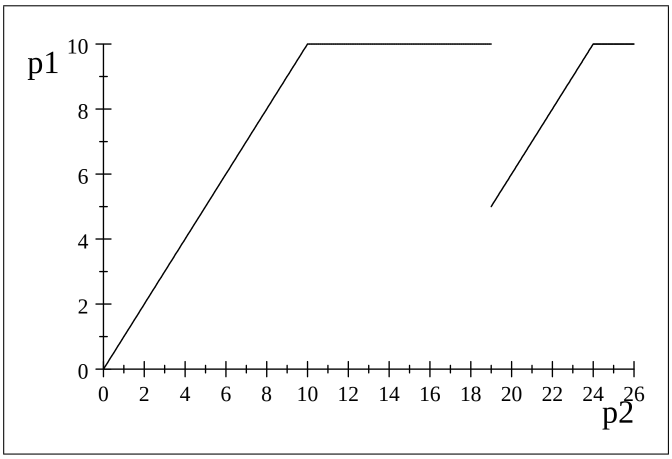

Figure 10a): Firm 1's best response Curve

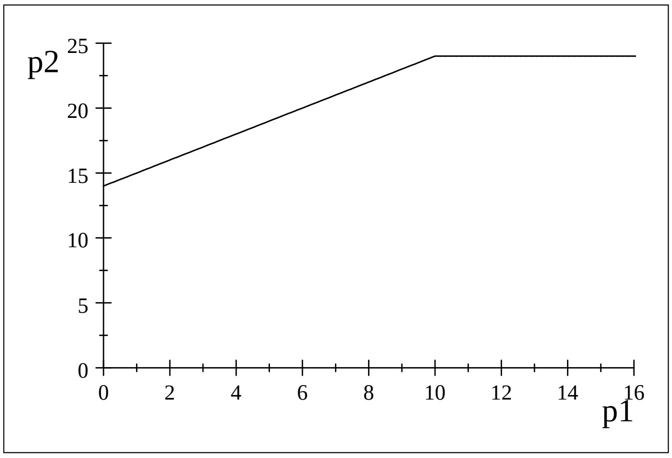

Figure 10b): Firm 2's Best Response Curve

Step 2: Eliminating dominated strategies

According to best response functions and Figures 10(a-b) above, we can see that firm 2 will never price below d or above $V + d$, which means that Firm 1 will not price below $\frac{V}{2}$ or above V. This in turn implies that Firm 2 will not price below $\frac{V}{2} + d$ or above $V + d$, which implies that Firm 1 will not price below $\frac{V}{2}$ or above V. As a result, the final price supports for the two firms in the "reduced" game are: Firm 1 $\left(\frac{V}{2}, V\right)$, Firm 2 $\left(\frac{V}{2} + d, V + d\right)$. To derive the cumulative distribution functions for each firm, we assume there is a mass point for Firm 1 at the top of its price support (V) with probability m_1.

Step 3: Derive equilibrium of the reduced pricing game.

We now derive the pricing equilibrium of the reduced game using the condition that expected profits must be equal from all strategies which are being played with positive probability.

For Firm 1, if it chooses a price marginally less than $\frac{V}{2}$ it captures demand from both consumers with $\pi_1 = 2\frac{V}{2} = V$ in the limit. If Firm 1 prices at V, it captures the demand from Mr. Jones for sure, but not Mr. Brown given Firm 2's price support, again $\pi_1 = V$. Denote $F_2(.)$ to be Firm 2's CDF in equilibrium, $\forall p_1 \in \left(\frac{V}{2}, V\right)$.

$$\pi_1 = p_1 \left(1 + 1 \left(1 - F_2 \left(p_1 + d\right)\right)\right) = V \tag{i}$$

Solving equation (A1) yields $F_2(p) = 2 - \frac{V}{(p-d)}$, $\forall p \in \left(\frac{V}{2} + d, V + d\right)$.

For Firm 2, if it prices slightly below $\frac{V}{2} + d$, Firm 2 captures the demand from Mr. Brown but not Mr. Jones, $\pi_2 = \frac{V}{2} + d$ in the limit. If Firm 2 prices slightly less than $V + d$, it will not capture demand from Mr. Jones and it will obtain demand from Mr. Brown when Firm 1 is pricing at its mass point of V. This implies that $\pi_2 = (V + d)\, m_1$. By the equal profit condition, we can write:

$$\left(\frac{V}{2} + d\right) = (V + d)\, m_1 \tag{ii}$$

which yields $m_1 = \frac{V+2d}{2(V+d)}$.

Denote $F_1(.)$ to be Firm 1's CDF in equilibrium, $\forall p_2 \in \left(\frac{V}{2}+d, V+d\right)$:

$$\pi_2 = p_2 \left(1 \left(1 - F_1 \left(p_2 - d\right)\right)\right) = \left(\frac{V}{2} + d\right) \tag{iii}$$

Solving equation (A3) yields $F_1(p) = 1 - \frac{V+2d}{2(p+d)}$, $\forall p \in \left(\frac{V}{2}, V\right)$.

This completes the proof of Proposition 1. **Q.E.D.**

Proof for Lemma 1

Anticipating the equilibrium outcome from the price competition with Firm 1 upon entry, Firm 2 chooses his level of drastic innovation by maximizing $\pi_2 = \left(\frac{V}{2}+d\right) - \frac{\gamma}{2}(d)^2$. The optimal d^*, π_2^* reported in Lemma 1 result from taking first order partial derivative of π_2 with respect to d and checking the negativeness of second order condition. This completes the proof of Lemma 1. **Q.E.D.**

Proof for Proposition 3

We proceed through a similar process to Steps 1 & 2 in the proof of Proposition 1. It can be shown that the best response correspondences and the price supports in the "reduced" game are not affected by the existence of positive product cost for the innovative product. The thing that changes is the resulting profits of Firm 2. Again we assume there is a mass point for Firm 1 at the top of its price distribution (V) with probability m_2.

For Firm 1, if it prices slightly less than $\frac{V}{2}$, it will capture demand from both consumers with $\pi_1 = 2\frac{V}{2} = V$ in the limit. If Firm 1 prices at V, it obtains demand from Mr. Jones but not Mr. Brown given Firm 2's price support. As before, $\pi_1 = V$. We denote $F_2(.)$ to be Firm 2's CDF in equilibrium, $\forall p_1 \in \left(\frac{V}{2}, V\right)$

$$\pi_1 = p_1 \left(1 + 1 \left(1 - F_2 \left(p_1 + d\right)\right)\right) = V \tag{iv}$$

Solving equation (A4) yields $F_2(p) = 2 - \frac{V}{p-d}$, $\forall p \in \left(\frac{V}{2}+d, V+d\right)$.

For Firm 2, if it prices slightly less than $\frac{V}{2}+d$, it captures demand from Mr. Brown but not from Mr. Jones, $\pi_2 = \frac{V}{2}+d-c$ in the limit. If Firm 2 prices slightly below $V+d$, it will not capture demand from Mr. Jones and it captures demand from Mr. Brown when Firm 1 is pricing at its mass point of V which implies that $\pi_2 = (V+d-c)\, m_2$. By the equal profit condition, we can write:

$$\frac{V}{2} + d - c = (V + d - c)\, m_2 \tag{v}$$

which yields $m_2 = \frac{V+2(d-c)}{2(V+d-c)}$ (Note $m_2 = m_1$ if $c = 0$).

Denote $F_1(.)$ to be Firm 1's CDF in equilibrium, $\forall p_2 \in \left(\frac{V}{2}+d, V+d\right)$

$$\pi_2 = (p_2 - c)\left(1 - F_1\left(p_2 - d\right)\right) = \left(\frac{V}{2} + d - c\right) \tag{vi}$$

Solving equation (A6) yields $F_1(p) = 1 - \frac{V+2(d-c)}{2(p+d-c)}$, $\forall p \in \left(\frac{V}{2}, V\right)$.

This completes the proof of Proposition 3. **Q.E.D.**

Proof for Proposition 4

The two innovation options can be derived via the similar process as in Lemma 1. In particular, $\pi_2^{*'} = \frac{\gamma V+1}{2\gamma} - f_d$ for drastic innovation, $\pi_2^{**''} = \frac{1}{2\gamma} - f_g$ for general improvement. $\pi_2^{*'} - \pi_2^{**''} = \frac{V}{2} - f_d + f_g > 0$ if $f_d < \frac{V}{2} + f_g$. This completes the proof of Proposition 4. **Q.E.D.**

Proof for Proposition 5

Following similar derivation as in that of Lemma 1, we can solve for the optimal levels of innovation under two options to be $d' = \frac{1}{\gamma_d}$ and $g' = \frac{1}{2\gamma_g}$ respectively. Note that $d' > V$ requires $\gamma_d < \frac{1}{V}$, $g' < d'$ requires $\frac{\gamma_d}{2} < \gamma_g$.

Comparing the new equilibrium profits under the two innovation options ($\pi_2^{*\hat{}} = \frac{V\gamma_d+1}{2\gamma_d}$ for drastic innovatioin, $\pi_2^{**\hat{}} = \frac{1}{2\gamma_g}$ for general improvement), $\pi_2^{*\hat{}} - \pi_2^{**\hat{}} = \frac{-\gamma_d+\gamma_g+V\gamma_d\gamma_g}{2\gamma_d\gamma_g} < 0$ if $\gamma_g < \frac{\gamma_d}{\gamma_d V+1}$. Note that $\frac{\gamma_d}{\gamma_d V+1} - \frac{\gamma_d}{2} = -\frac{\gamma_d(V\gamma_d-1)}{2(V\gamma_d+1)} > 0$, which implies that $\frac{\gamma_d}{2} < \gamma_g < \frac{\gamma_d}{\gamma_d V+1}$ is not an empty set. This completes the proof of Proposition 5. **Q.E.D.**

Proof for Proposition 6

We proceed through a similar process as Step 1 in the proof of Proposition 1 to derive the two firms' best response correspondences.

Given Firm 1's price p_1, Firm 2's best response can be summarized as:

$$BR_2(p_1) = \begin{cases} p_2 = p_1 + d & \text{if} \quad p_1 \le V \\ p_2 = V + d & \text{if} \quad p_1 > V \end{cases}$$

Given Firm 2's price p_2, Firm 1's best response can be summarized as:

$$BR_1(p_2) = \begin{cases} p_1 = p_2 & \text{if} \quad p_2 \le V \\ p_1 = V & \text{if} \quad V < p_2 \le \frac{V}{3} + d \\ p_1 = p_2 - d & \text{if} \quad \frac{V}{3} + d < p_2 \le V + d \\ p_1 = V & \text{if} \quad p_2 > V + d \end{cases}$$

Through a similar process to Steps 2 in the proof of Proposition 1, the final price supports for the two firms in the "reduced" game are found to be: Firm 1 $\left(\frac{V}{3}, V\right)$, Firm 2 $\left(\frac{V}{3} + d, V + d\right)$. Again we assume there is a mass point for Firm 1 at the top of its price support (V) with probability m_3.

For Firm 1, if it chooses a price marginally less than $\frac{V}{3}$ it captures demand from all three consumers with $\pi_1 = 3\frac{V}{3} = V$ in the limit. If Firm 1 prices at V, it captures the demand from Mr. Jones for sure, but not the two Mr. Browns given Firm 2's price support, again $\pi_1 = V$. Denote $F_2(.)$ to be Firm 2's CDF in equilibrium, $\forall p_1 \in \left(\frac{V}{3}, V\right)$.

$$\pi_1 = p_1 \left(1 + 2\left(1 - F_2(p_1 + d)\right)\right) = V \tag{vii}$$

Solving equation (A7) yields $F_2(p) = \frac{3}{2} - \frac{V}{2(p-d)}$, $\forall p \in \left(\frac{V}{3} + d, V + d\right)$.

For Firm 2, if it prices slightly below $\frac{V}{3}+d$, Firm 2 captures the demand from two Mr. Browns but not Mr. Jones, $\pi_2 = 2\left(\frac{V}{3}+d\right)$ in the limit. If Firm 2 prices slightly less than $V+d$, it will not capture demand from Mr. Jones and it will obtain demand from the two Mr. Browns when Firm 1 is pricing at its mass point of V. This implies that $\pi_2 = (V+d)(2m_3)$. By the equal profit condition, we can write:

$$2\left(\frac{V}{3}+d\right) = (V+d)(2m_3) \tag{viii}$$

which yields $m_3 = \frac{V+3d}{3(V+d)}$.(Note this is less than $m_1 = \frac{V+2d}{2(V+d)}$ in the main model)

Denote $F_1(.)$ to be Firm 1's CDF in equilibrium, $\forall p_2 \in \left(\frac{V}{2}+d, V+d\right)$:

$$\pi_2 = p_2\left(2\left(1-F_1\left(p_2-d\right)\right)\right) = 2\left(\frac{V}{3}+d\right) \tag{ix}$$

Solving equation (A9) yields $F_1(p) = 1 - \frac{V+3d}{3(p+d)}$, $\forall p \in \left(\frac{V}{3}, V\right)$. This completes the proof of Proposition 6. **Q.E.D.**

Proof for Proposition 7

We proceed through a similar process to Step 1 in the proof of Proposition 1 to derive the two firms' best response correspondences.

Given Firm 1's price p_1, firm 2's best response can be summarized as:

$$BR_2(p_1) = \begin{cases} p_2 = p_1 + d & \text{if} \quad p_1 \le V \\ p_2 = V + d & \text{if} \quad p_1 > V \end{cases}$$

Notice that if $d > 2V$, it is best for Firm 2 to price at $V+d$ when $p_1 > V$. Otherwise, the best response of Firm 2 is to price at V when $p_1 > V$.

Given Firm 2's price p_2, Firm 1's best response can be summarized as:

$$BR_1(p_2) = \begin{cases} p_1 = p_2 & \text{if} \quad p_2 \le V \\ p_1 = V & \text{if} \quad V < p_2 \le \frac{2V}{3}+d \\ p_1 = p_2 - d & \text{if} \quad \frac{2V}{3}+d < p_2 \le V+d \\ p_1 = V & \text{if} \quad p_2 > V+d \end{cases}$$

Through a similar process to Steps 2 in the proof of Proposition 1, the final price supports for the two firms in the "reduced" game are found to be: Firm 1 $\left(\frac{2V}{3}, V\right)$, Firm 2 $\left(\frac{2V}{3}+d, V+d\right)$. Again we assume there is a mass point for Firm 1 at the top of its price support (V) with probability m_4.

For Firm 1, if it chooses a price marginally less than $\frac{2V}{3}$ it captures demand from all three consumers with $\pi_1 = 3\frac{2V}{3} = 2V$ in the limit. If Firm 1 prices at V, it captures the demand from the two Mr. Jones for sure, but not Mr. Brown given Firm 2's price support, again $\pi_1 = 2V$. Denote $F_2(.)$ to be Firm 2's CDF in equilibrium, $\forall p_1 \in \left(\frac{2V}{3}, V\right)$.

$$\pi_1 = p_1\left(2 + 1\left(1 - F_2\left(p_1+d\right)\right)\right) = 2V \tag{x}$$

Solving equation (A10) yields $F_2(p) = 3 - \frac{2V}{p-d}$, $\forall p \in \left(\frac{2V}{3}+d, V+d\right)$.

For Firm 2, if it prices slightly below $\frac{2V}{3}+d$, Firm 2 captures the demand from Mr. Brown but not the two Mr. Jones, $\pi_2=\frac{2V}{3}+d$ in the limit. If Firm 2 prices slightly less than $V+d$, it will not capture demand from the two Mr. Jones and it will obtain demand from Mr. Brown when Firm 1 is pricing at its mass point of V. This implies that $\pi_2=(V+d)\,m_4$. By the equal profit condition, we can write:

$$\frac{2V}{3}+d=(V+d)\,m_4 \tag{xi}$$

which yields $m_4=\frac{2V+3d}{3(V+d)}$.(Note this is greater than $m_1=\frac{V+2d}{2(V+d)}$ in the main model)

Denote $F_1(.)$ to be Firm 1's CDF in equilibrium, $\forall p_2\in\left(\frac{2V}{3}+d,V+d\right)$:

$$\pi_2=p_2\left(1\left(1-F_1\left(p_2-d\right)\right)\right)=\frac{2V}{3}+d \tag{xii}$$

Solving equation (A12) yields $F_1(p)=1-\frac{2V+3d}{3(p+d)}$, $\forall p\in\left(\frac{2V}{3},V\right)$.

For optimal level of d, Firm 2 maximizes $\pi_2=\left(\frac{2V}{3}+d\right)-\frac{\gamma}{2}(d)^2$, which yields $d^{**}=\frac{1}{\gamma},\pi_2^{**}(d)=\frac{4V\gamma+3}{6\gamma}$. $d^{**}>2V$ if $\gamma<\frac{1}{2V}$. Same as in the main model, if choosing the option of general product improvement, Firm 2 will get all three consumers in the market by pricing slightly below g. For optimal level of g, Firm 2 maximizes $\pi_2=3g-\frac{\gamma}{2}(3g)^2$, which yields $g^{**}=\frac{1}{3\gamma},\pi_2^{**}(g)=\frac{1}{2\gamma}$. $g^{**}<V$ if $\gamma>\frac{1}{3V}$. Finally $\pi_2^{**}(d)-\pi_2^{**}(g)=\frac{2}{3}V>0$. This completes the proof of Proposition 6. **Q.E.D.**