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Context-Dependent Preferences and Innovation Strategy

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Disruptive innovations introduce a new performance dimension into a product category, but often suffer from inferior performance on key performance dimensions of their existing substitutes. Hence, the followers of these innovations face an important decision to make: they must choose to improve the new technology either on the key performance dimension shared with the old technology or on the new performance dimension. This paper investigates which path firms should choose when they face such a dilemma in the absence of any cost or capability issues. In doing so, we integrate customer response into the theory of technological evolution and allow preferences on the product choices to be context dependent. We show that context-dependent preferences may encourage the follower to improve the new technology on the new performance dimension. Later, we extend our game to a dynamic one and show that the context-dependent preferences may cause the pioneer to innovate less.

Key words: context-dependent preferences; new product development; entry strategy
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1. Introduction

Evolution of technology has a profound impact on market competition. Disruptive technological innovations may help a once small firm, such as Intel, to become a market leader, but they may also cause a once dominant product, such as Kodak film, to lose its relevancy to consumers. At its early stage, a disruptive innovation that introduces a new performance dimension into a product category often suffers from inferior performance on some key performance dimensions of their existing substitutes (Christensen 1997, Sood and Tellis 2011). For example, the first generation of compact digital cameras offered lower resolution than typical optical cameras and the first generation of MP3 devices had lower sound quality than CDs. Therefore, the followers of the new technology face an important decision to make: they must choose to improve the new technology either on the key performance dimension shared with the old technology (and hence try to catch up with the products based on the old technology) or on the new performance dimension. There are examples of firms pursuing either strategy. For example, in the case of digital cameras and MP3 players, the early development among participating firms had been on the data transferring to personal computers before considerable efforts were made to improve the resolution of digital cameras and the sound quality of MP3 players. Similarly, in the case of hybrid cars, the early development had been on battery and fuel efficiency rather than on performance (Rowley 2007). On the other hand, 3.5-inch drivers showed a steady improvement in hard disk capacity since the early days of their introduction (Christensen and Bower 1996).

In this paper, by using an analytical model, we investigate which path firms should choose when they face such a dilemma in the absence of any cost or capability issues.[1] More specifically, we explore when it is a profit maximizing act for an early follower of a disruptive technological innovation to improve the course of innovation path on the new performance direction rather than try to catch up on the established performance dimensions when it is able to do either at the same cost. We call the former strategy revolutionary, whereas the latter one is conservative. We then investigate the optimal innovation strategy for the pioneer firm of the new technology given the anticipated innovation path of its follower. In doing so, we integrate customer response into the

[1] As an interesting historical fact, the digital camera technology was first developed by NASA scientists in 1960s, to whom the ability of taking and transfering high-quality images remotely was the priority.

theory of technological evolution and also allow consumers to exhibit context-dependent preferences on the product choices. Consumer behavioral researchers have documented through experiments that when consumers make a choice among a set of objects, they evaluate options by considering both their absolute utilities and their relative standing in the choice set, and this process leads to context-dependent preferences (Huber et al. 1982, Tversky and Simonson 1993, Simonson and Tversky 1992, Drolet et al. 2000, Bhargava et al. 2000). As the preference structure changes from context to context, choice reversals can happen across contexts. It has been suggested that consumers compare each option with a reference point that is endogenous to the choice set (Kivetz et al. 2004a, b), and in comparative valuation, losses loom larger than gains. The reference dependence and loss aversion together cause choice reversals across context (i.e., context-dependent preferences). Context-dependent preferences are especially relevant for consumers' adoption of technology innovation because the reference points of product attributes in consumers' minds are likely to evolve over time with the advance of technology and the arrival of new products in the market; this influences consumers' adoption of products with new technology and consequently firms' innovation strategies.

We model the competition between a pioneer firm, whose product introduces a new performance dimension but performs worse than the product based on the old technology on the established performance dimension, and its follower in new technology. We derive the equilibrium outcome of their innovation strategies as well as pricing decisions. There are two types of consumers in our model: conservative type of consumers value the old (i.e., established) performance attribute more than the new performance attribute, whereas nonconservative consumers value both attributes equally.

In the absence of context-dependent preferences, the follower in our model always prefers to improve the technology on the established performance dimension, i.e., adopts the conservative strategy, as suggested by the S-curve theory (Christensen 1997). However, when the consumers exhibit context-dependent preferences, under certain conditions the follower prefers to improve the technology on the new performance dimension, i.e., adopts the revolutionary strategy. This happens because the entry of the follower under the revolutionary strategy causes the reference point for the new performance dimension to shift upward and the reference point for the old performance dimension to shift downward, which in turn increases the value of the pioneer product based on the new technology relative to the product based on the old technology for the conservative segment. Furthermore, compared with the conservative consumers, nonconservative consumers are willing to pay an even higher premium for the follower's product over the pioneer's product under the revolutionary strategy than under the conservative strategy. Consequently, the pioneer firm on new technology and its follower may focus on serving conservative consumers and nonconservative consumers, respectively. This differentiated focus on different consumer segments leads to lessened price competition and thus gives a strong incentive to the follower to adopt the revolutionary strategy. This result shows the importance of understanding context-dependent consumer preferences on the development of firms' optimal innovation strategies. In particular, context-dependent consumer preferences may speed up the innovation on the new performance dimension introduced by new technology (e.g., data transfer of digital cameras and battery efficiency of hybrid cars). We also confirm that the follower would still prefer to pursue the revolutionary strategy even if it can improve the new product technology in both performance dimensions equally at the same time without an additional cost (we call this the middle-road strategy).

Later, we extend our basic model to a dynamic one and allow the pioneer firm of the technological innovation to choose its initial positioning foreseeing the entry of the follower. Interestingly, we find that the existence of context-dependent preferences may decrease the pioneer's incentive to locate at a technologically advanced position on the established performance dimension. In the absence of context-dependent preferences, there are two types of benefits for the pioneer to locate at a technologically advanced position. On one hand, the pioneer earns higher monopoly profits in the first product development cycle prior to the entry of the follower firm (i.e., there is a direct benefit). On the other hand, when the pioneer locates at a technologically advanced position on the established performance dimension, the follower prefers the revolutionary strategy to the conservative strategy. Because the pioneer earns higher duopoly profits under the revolutionary strategy of the follower than under the conservative strategy of the follower, there is also a strategic benefit of locating at a technologically advanced position. However, with the presence of context-dependent consumer preferences the follower is more likely to pursue the revolutionary strategy when the pioneer locates at a technologically inferior position on the established performance dimension than when the pioneer locates at a technologically more advanced position. As a result, the strategic benefit of locating at a technologically advanced position may disappear, which in turn decreases the pioneer's incentive to incur a higher research and development (R&D) cost for a technologically advanced position. Consequently, this path of technology innovation endogenously triggers the diffusion of new technology: the nonconservative consumers always adopt the product with the latest technologies and the conservative consumers start their new technology adoption later.

The rest of this paper is organized as follows. In §2, we discuss how our work is related to the extant literature. We lay out the model setup in §3 and solve for the basic model in §4. In §5, we allow the follower to improve the new product technology in both performance dimensions equally at the same time without an additional cost. In §6, we investigate how the existence of context-dependent preferences affects the monopolist's decision whether to pursue the revolutionary or conservative strategy to upgrade its product line. Section 7 extends our basic model to a dynamic one and investigates the pioneer's choice of product innovation. Finally, §8 concludes the paper with the discussions on the implications of our results and future research directions.

2. Literature Review

The popularly held view on the pattern of disruptive innovations suggests that the performance of the new technologies on the key product performance dimension follows an S-shaped path over time and improvement occurs sequentially from the first key performance dimension established in the product category to the next one (Christensen 1997). Although these innovations initially do not serve to the mainstream consumers who care mostly about the established performance dimension, further development raises the disruptive technologies' performance on the established performance dimension to a level sufficient to satisfy the mainstream consumers and hence disrupts the old technology's market. However, the recent empirical research proves that there are incidences of firms pursuing the path that we call in this paper the revolutionary strategy. Sood and Tellis (2005) show that the technological evolution of 9 out of 14 technologies from desktop memory, display monitors, desktop printers, and data transfer markets follows a step function, with periods of stagnant performance improvement interrupted by discontinuous jumps on the key performance dimension shared by all technologies in the category. Furthermore, it has been observed that the innovations on multiple product dimensions do not occur sequentially, so it is not generally true that firms always focus on innovations along the first performance dimension before shifting to the second one. Sood and Tellis (2011) also echo this not so uncommon outcome based on their analysis of 36 technologies from external lighting, desktop memory, display monitors, desktop printers, data transfer, music recording, and analgesics markets.

Furthermore, in their review paper on innovation Hauser et al. (2006) criticize the S-curve theory as being very much a supply side and technology centric one. According to the authors, the theory lacks consumer perspective and does not provide any normative tool for technology selection early in the product development. Therefore, they suggest that future research should integrate a customer-oriented approach into technology entry and early development to help managers to decide which path to pursue. In the extant literature there are only a few papers integrating the customer perspective into the S-curve theory, and none of those papers allows context-dependent consumer preferences but rather assumes stable preferences over time. Among them, Adner (2002) models the heterogeneity in consumers' preferences for different product attributes. By using computer simulations, he shows that if there is enough overlap in different segments' preferences for product attributes and the preference overlap is asymmetric (i.e., one technology casts a larger performance shadow on its rival's market), then technology disruptions happen as suggested by the S-curve theory. As suggested by Christensen (1997), this outcome is caused by performance oversupply—i.e., as consumers' marginal returns from performance improvements decrease, technologies that offer lower relative performance at lower price become more attractive. Adner (2002) allows firms both to determine the technology's development trajectory by investing in product innovation to enhance the performance of their technologies and to invest in process innovation to reduce their costs. Similarly, Adner and Zemsky (2005) formalize the conditions under which the new technologies disrupt the established ones, as suggested by Christensen (1997), by modeling the heterogeneity in consumers' preferences for different product attributes. The authors model two customer segments such that the primary segment cares more about the traditional performance dimension, whereas the secondary segment cares more about the new performance dimension. The paper claims that a monopolist new-technology firm should prefer to invest in the established performance dimension. However, unlike our paper, in their paper technological improvement is exogenous and firms only choose their output levels. Finally, by modeling the heterogeneity in consumers' preferences for different product attributes and using data from a phone market, Druehl and Schmidt (2008) show that, contrary to the popular belief that disruptive innovations are cheap, expensive disruptive innovations can exist. In their paper, technology progress is exogenous and firms only make their pricing decisions.

Our paper contributes to the extant literature by integrating the consumers' context-dependent preference into the formal analysis of firms' decisions regarding which path to pursue in the phases of new technology's entry and early development. As our results show, taking into consideration context-dependent preferences of consumers may lead to firm behavior that is different from the conventional view. In fact, it has been suggested that marketing researchers should integrate reference-dependence and loss aversion in their models when investigating firm behavior. Narasimhan et al. (2005), in a review of the existing literature, argue for future research to incorporate such behavioral assumptions to examine firms' strategies (see also Ho et al. 2006). In this aspect, our paper also adds to the growing marketing literature that adopts the behavioral economic paradigm to provide insights on marketing phenomena and firms' strategies (Amaldoss and Jain 2005a, b, 2008, 2010; Chen et al. 2010; Chen and Cui 2013; Cui et al. 2007; Feinberg et al. 2002; Hardie et al. 1993; Ho and Zhang 2008; Jain 2009; Lim and Ho 2007; Orhun 2009; Syam et al. 2008; Kuksov and Villas-Boas 2010; Ofek et al. 2007).

3. Model Setup

In the current period, there are two products in the market. One product is based on the old product technology (such as an optical camera), whereas the other one is the pioneer product based on a new product technology (such as the first digital camera). We will denote the former one as y_0 and the latter one as y_1. Products consist of three attributes: price, attribute A, and attribute B. Attribute A is the main performance dimension of the old product technology and attribute B is the new performance dimension introduced by the new product technology. The product y_0 provides a utility of a on attribute A dimension and zero utility on attribute B dimension. The product y_1 provides a utility of b on attribute B dimension and zero utility on attribute A dimension. The old product technology has been around for awhile, and thus y_0 is competitively supplied.[2] The pioneer firm of the new product technology incurs an R&D cost of D_1 to develop y_1. Figure 1 depicts the location of y_0 and y_1 on the two attribute dimensions.

At $t = 1$ an entrant is contemplating to develop an advanced product, y_2, based on the new product technology. The entrant (hereafter, the follower) can choose to invest in improving in attribute A dimension and locate its new product at (x, b) or invest in

Figure 1 Location of the Products in the Current Period

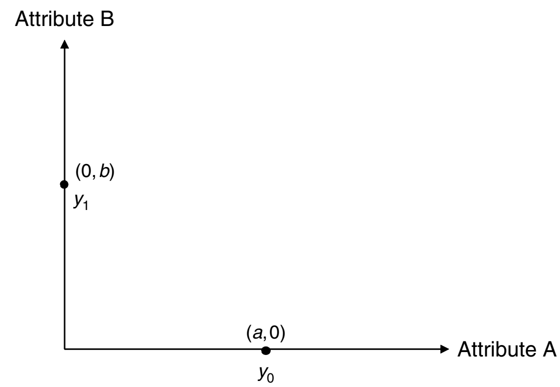
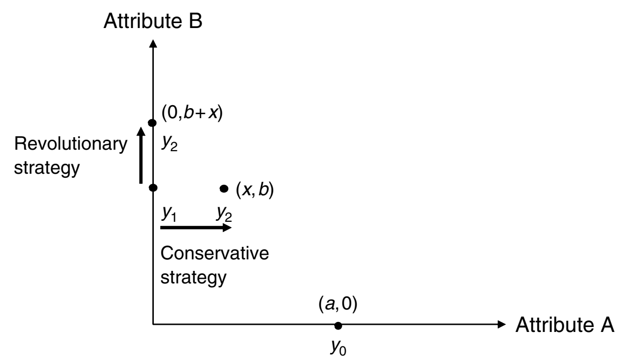


Figure 2 Conservative Strategy vs. Revolutionary Strategy



improving in attribute B dimension and locate its new product at $(0, b+x)$. We will call the former strategy the conservative strategy and the latter one the revolutionary strategy. We denote the follower's strategy choice with superscripts cons and rev. Thus, y_2^{cons} denotes the follower's product when it pursues the conservative strategy and y_2^{rev} denotes the follower's product when it pursues the revolutionary strategy. Figure 2 depicts the possible locations for y_2.

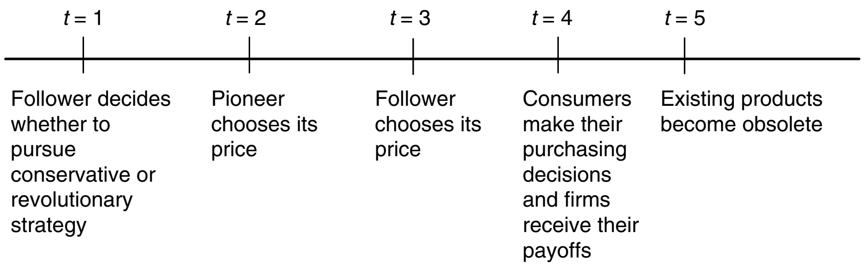
It costs D_2, where $D_2 > D_1$, to improve in either attribute.[3] To simplify our analysis, we normalize the manufacturing cost to zero for all the products. After the follower chooses its strategy, at $t = 2$ the pioneer firm (who owns y_1) makes its pricing decision and at $t = 3$ the follower makes its pricing decision. We acknowledge that the sequential pricing assumption is not very appealing. This assumption is made to avoid mixed strategy equilibrium and to make our analysis tractable.[4] Consumers with a market size of 1 are aware of the new technology and at $t = 4$ make their purchasing decision among

[2] In fact, our results are enacted as long as there is more than one firm supplying y_0.

[3] We assume that D_2 is small enough to pursue either strategy.

[4] We have also examined a model similar to the basic model here but modified to ensure the existence of pure strategy equilibrium and are able to obtain qualitatively similar results. The details of this analysis are provided in the online technical appendix (available from the authors upon request).

Figure 3 **Timeline of the Game**



y_0, y_1, and y_2. Those consumers once owned a product based on the old product technology (e.g., an optical camera) before the products based on the new technology become available. When the follower pursues the conservative strategy, consumers' choice set is $\{y_0, y_1, y_2^{\text{cons}}\}$, and when the follower pursues the revolutionary strategy, consumers' choice set is $\{y_0, y_1, y_2^{\text{rev}}\}$. Each consumer buys at most one unit in the product category, and there are two types of consumers in the market. An α proportion of consumers values old performance attribute (attribute A) more than the new performance attribute (attribute B), whereas the remaining $(1-\alpha)$ proportion of consumers values both attributes A and B equally. We call the former segment conservative (denoted as c) and the latter one nonconservative (denoted as nc). Our choice of modeling heterogeneity in consumer preferences for different product attributes is in line with the disruptive innovation literature (for a similar approach, see Adner and Zemsky 2005, Sood and Tellis 2011). Finally, at $t = 5$ both y_1 and y_2 become obsolete as a far more advanced new generation of products enter the market. Figure 3 depicts the timeline of the game.

4. Analysis

In the following section, we characterize the subgame perfect Nash equilibrium of the game (Fudenberg and Tirole 1991) presented in §3. Initially we assume that the location of y_1 is given as $(0, b)$. Later, in §7, we relax this assumption and extend the timeline so that the pioneer firm can also choose y_1's location. We will first investigate the benchmark case and characterize the follower's new product development decision when consumer preferences are not context dependent. In §4.2, we consider the context-dependent preferences of consumers and analyze how the existence of context-dependent preferences affects the follower's decision whether to pursue the conservative or the revolutionary strategy.

4.1. Benchmark Case

To start we will solve for the follower's decision whether to pursue the conservative or the revolutionary strategy in the absence of context-dependent preferences. The utility functions of consumers are specified as follows.

Under the Conservative Strategy. A conservative consumer's utility is equal to a if he buys y_0, to $\rho b - price_{y_1}^{\text{cons}}$ if he buys y_1, and to $\rho b + x - price_{y_2}^{\text{cons}}$ if he buys y_2. A nonconservative consumer's utility is equal to a if he buys y_0, to $b - price_{y_1}^{\text{cons}}$ if he buys y_1, and to $b + x - price_{y_2}^{\text{cons}}$ if he buys y_2.

Under the Revolutionary Strategy. A conservative consumer's utility is equal to a if he buys y_0, to $\rho b - price_{y_1}^{\text{rev}}$ if he buys y_1, and to $\rho(b + x) - price_{y_2}^{\text{rev}}$ if he buys y_2. A nonconservative consumer's utility is equal to a if he buys y_0, to $b - price_{y_1}^{\text{rev}}$ if he buys y_1, and to $b + x - price_{y_2}^{\text{rev}}$ if he buys y_2.[5]

Note that unless $b > a$, the pioneer firm cannot sell y_1 to anyone (not even to the nonconservative segment) even in the absence of y_2. Therefore, we conduct the rest of our analysis for $b > a$. Otherwise, the pioneer would not enter the market in the first place. Note that the conservative segment in our model coincides with mainstream segment in the extant literature for whom the new technology does not provide sufficient performance to be preferred over the established technology (Christensen 1997, Adner 2002, Adner and Zemsky 2005, Sood and Tellis 2011). Therefore, we assume $\rho b = a$, where $\rho < 1$, so that initially the conservative segment would not be willing to buy y_1.

Lemma 1. *In the absence of context-dependent preferences, the follower always prefers to pursue the conservative strategy.*

Lemma 1 basically replicates the evolution pattern that discontinuous innovations follow as indicated in the previous literature; that is, the innovation smoothly improves and catches up to the existing technology on the key performance dimension established in the category by following the shape of an S-curve. The intuition of this lemma is quite simple. When the follower pursues the conservative strategy,

[5] Consumer utility functions are also summarized in Table A.1 in the appendix.

both consumer segments obtain a gain of x in utility comparing to the utility from y_1. When the follower pursues the revolutionary strategy, however, the nonconservative consumers experience a gain of x in utility and the conservative consumers obtain a gain of ρx in utility, which is less than x. Therefore, it is not surprising that the follower chooses to offer y_2^{cons} because it is a "better" product than y_2^{rev}.

Next, we solve for the follower's decision when consumers' preferences are context dependent and investigate whether the follower's decision regarding on which dimension (the key performance dimension established in the product category or the new performance dimension introduced by the new technology) to improve the new technology changes or not.

4.2. With Context-Dependent Preferences

To implement context-dependent preferences, we adopt the linear loss-aversion model (LAM). This model is empirically proven as one of the best models to implement context effects (see Kivetz et al. 2004a, b)[6] and used by some recent papers, such as Ho et al. (2006), Koszegi and Rabin (2006), and Orhun (2009), for modeling purposes. In this model, consumers' utility is the sum of absolute utilities from each valued attribute (i.e., consumption valuation) and relative utilities, which consist of the sum of gains and losses on each attribute compared to a reference point (i.e., comparative valuation). Furthermore, in comparative valuation, losses loom larger than gains (i.e., the deviations from the reference point have a greater impact when they are losses than when they are gains). In this model consumers preferences are reference dependent (i.e., the utility consumers derives from a product depends on the reference point) and the reference point is endogenous to the choice set (Kivetz et al. 2004a, Orhun 2009). This means that consumers' preferences are context dependent.

We use the equal weighted average of the absolute utilities on attribute A dimension and on attribute B dimension as the reference point for attribute A and attribute B, respectively. Kivetz et al. (2004b) and Orhun (2009) show that linear LAM model with a reference point as the centroid of all products can capture all the context effects such as the extremeness aversion, asymmetric dominance, asymmetric advantage, enhancement, and detraction effects (Huber et al. 1982, Simonson and Tversky 1992). Thus, in our model the reference point for attribute A is equal to $(a+x)/3$ under conservative strategy and equal to $a/3$ under the revolutionary strategy. The reference point for attribute B is equal to $2b/3$ under the conservative strategy and equal to $(2b+x)/3$ under the revolutionary strategy. We use zero as the reference price. According to the existing literature on reference price (see Rajendran and Tellis 1994, Mazumdar et al. 2005, Park et al. 2000), there are both contextual and temporal components in reference prices. Although the contextual component is the lowest price in the price range of the choice set, the temporal component (also called an internal reference price) is the past price of the consumer's favorite brand. Note that in our model the lowest price in consumers' choice set is zero (i.e., the price of y_0), and in the past the consumers bought y_0 at zero price. Hence, our choice of zero as the reference price is in line with the existing literature. Nevertheless, later we relax this assumption by using equally weighted averages of prices in the choice set as reference price and show that our results qualitatively stay the same. The details of this analysis are provided in the online technical appendix (available from the authors upon request).

Finally, to capture the loss aversion in our model, we use $\gamma > 0$ to denote the sensitivity to losses with respect to a reference point.[7]

Next, as we did in the benchmark case, we lay out consumers' utility functions under the conservative and under the revolutionary strategies. When consumers exhibit context-dependent preferences, their utility is the sum of absolute utilities from each attribute and comparative utility. Comparative utility is the sum of relative utilities that consist of the sum of gains and losses on each attribute compared to a reference point. Then, for a nonprice attribute, the comparative utility is equal to γ(*absolute utility* $-$ *reference utility*) $\cdot$ I(*absolute utility* $<$ *reference utility*), where $I(\textit{expression}) = 1$ if the expression in $I(\cdot)$ holds and $I(\textit{expression}) = 0$ otherwise. Since the reference price is zero, for price the comparative utility is equal to $\gamma(0 - \textit{price})$. Consumer utility functions in the presence of context-dependent preferences are given below. To make it easy for the readers to follow, we write the comparative utility part in parentheses.

Under the Conservative Strategy. Recall that the reference points for attributes A and B are equal to $(a+x)/3$ and $2b/3$, respectively. A conservative consumer's utility is equal to

$$a + \left[-\gamma\rho\frac{2b}{3} - \gamma\frac{x-2a}{3} I\left(\frac{a+x}{3} > a\right)\right] \quad \text{if he buys } y_0,$$

$$\rho b - price_{y_1}^{\text{cons}} + \left[-\gamma\frac{a+x}{3} - \gamma\, price_{y_1}^{\text{cons}}\right] \quad \text{if he buys } y_1,$$

[6] Kivetz et al. (2004a) show that validation and fit measures indicate that LAM is one of the three models that outperform the rest.

[7] Note that to reduce the number of parameters in our basic model, we assumed zero sensitivity to the gains with respect to a reference point. This assumption does not change at all the nature of our results.

$$\rho b+x-price_{y_2}^{cons}+\left[-\gamma\frac{a-2x}{3}I\left(\frac{a+x}{3}>x\right)-\gamma price_{y_2}^{cons}\right] \quad \text{if he buys } y_2.$$

A nonconservative consumer's utility is equal to

$$a+\left[-\gamma\frac{2b}{3}-\gamma\frac{x-2a}{3}I\left(\frac{a+x}{3}>a\right)\right] \quad \text{if he buys } y_0,$$

$$b-price_{y_1}^{cons}+\left[-\gamma\frac{a+x}{3}-\gamma\, price_{y_1}^{cons}\right] \quad \text{if he buys } y_1,$$

$$b+x-price_{y_2}^{cons}+\left[-\gamma\frac{a-2x}{3}I\left(\frac{a+x}{3}>x\right)-\gamma price_{y_2}^{cons}\right] \quad \text{if he buys } y_2.$$

Under the Revolutionary Strategy. Recall that the reference points for attribute A and attribute B are equal to $a/3$ and $(2b+x)/3$, respectively. A conservative consumer's utility is equal to

$$a+\left[-\gamma\frac{\rho(2b+x)}{3}\right] \quad \text{if he buys } y_0,$$

$$\rho b-price_{y_1}^{rev}+\left[-\gamma\frac{a}{3}-\gamma\rho\frac{x-b}{3}I\left(\frac{2b+x}{3}>b\right) -\gamma\, price_{y_1}^{rev}\right] \quad \text{if he buys } y_1.$$

$$\rho b+x-price_{y_2}^{rev}+\left[-\gamma\frac{a}{3}-\gamma\, price_{y_2}^{rev}\right] \quad \text{if he buys } y_2.$$

A nonconservative consumer's utility is equal to

$$a+\left[-\gamma\frac{2b+x}{3}\right] \quad \text{if he buys } y_0,$$

$$b-price_{y_1}^{rev}+\left[-\gamma\frac{a}{3}-\gamma\frac{(x-b)}{3}I\left(\frac{(2b+x)}{3}>b\right) -\gamma\, price_{y_1}^{rev}\right] \quad \text{if he buys } y_1,$$

$$b+x-price_{y_2}^{rev}+\left[-\gamma\frac{a}{3}-\gamma price_{y_2}^{rev}\right] \quad \text{if he buys } y_2.[8]$$

Proposition 1. *There exists an $\bar{\alpha}$ such that when consumers exhibit context-dependent preferences, if $0<x<a/2$ and $0<\alpha<\bar{\alpha}$, the follower prefers to pursue the revolutionary strategy in equilibrium. In equilibrium the pioneer sells to the conservative segment and the follower sells to the nonconservative segment.*

Proposition 1 shows that the existence of context-dependent preferences can change the follower's innovation strategy and as a result the evolution pattern of the new technology dramatically. Despite the seemingly strong incentive to pursue the conservative strategy, the consideration of context-dependent preferences, which calls for the follower to actively manage the context of consumer choice set, may lead the follower to pursue the revolutionary strategy. Figure 4(a) depicts the technological evolution under the condition presented in Proposition 1 (i.e., the follower engages in the revolutionary strategy), and Figure 4(b) depicts the technological evolution when the conditions presented in Proposition 1 do not hold (i.e., the follower engages in the conservative strategy). The equilibrium path of technological evolution as illustrated in Figure 4(a) goes against the popularly held view on the pattern of technological evolution that suggests that the performance of technologies on the key product performance dimension follows an S-shaped path over time and improvement occurs sequentially from the first key performance dimension established in the product category to the next one smoothly.

The intuition behind Proposition 1 is as follows. When the follower pursues the conservative strategy, the price premium that consumers are willing to pay for y_2 over y_1 is the same across the segments, which results in severe price competition leading to $price_{y_1}^{cons}=0$. However, when the follower pursues the revolutionary strategy, two things happen. On one hand, the reference point for attribute A shifts downward and the reference point for attribute B shifts upward. As a result of this, the price premium the conservative segment is willing to pay for y_1 over y_0 increases. On the other hand, the price premium that the nonconservative segment is willing to pay for y_2 over y_1 becomes higher than the price premium that the conservative segment is willing to pay. These create the possibility for the pioneer to serve the conservative segment with a positive price, and consequently for the follower to serve the nonconservative segment with a higher price than the price it would charge under conservative strategy. Thus, competition between the pioneer and the follower is mitigated under this scenario, which is equilibrium for small α values and small x values.[9] However, if α and/or x is large, the conservative segment is too important for the follower to give up, and hence the follower would not adopt the revolutionary strategy.

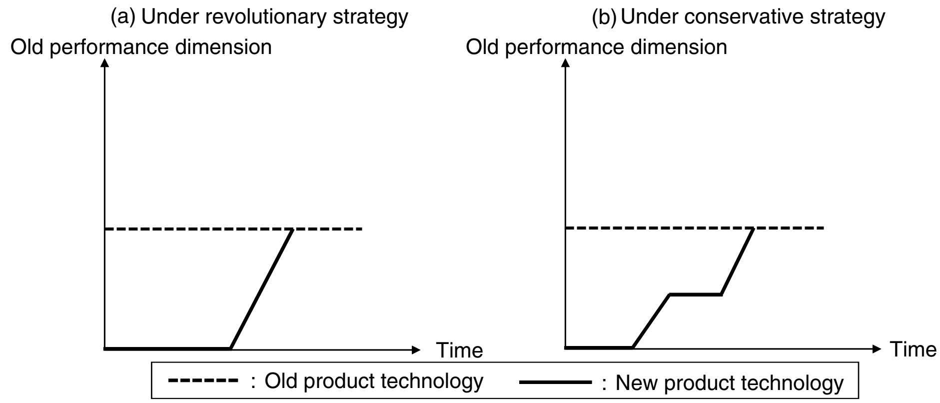
Next, we examine the comparative statics of firms' equilibrium prices and profits with regard to model parameters. The details of this analysis are provided in the online technical appendix.

Corollary 1. *Under the condition in Proposition 1, firms' equilibrium prices and profits increase in x for any*

[8] Consumer utility functions are also summarized in Tables A.2 and A.3 in the appendix.

[9] For example, if $b=3$, $a=2$, $x=0.2$, $\rho=\frac{2}{3}$, and $\gamma=1$, then for $\alpha<\frac{1}{7}$ the follower prefers to pursue the revolutionary strategy.

Figure 4 **Technological Evolution**



α values. However, firms' equilibrium prices and profits increase in γ and in ρ for lower α values and decrease in γ and in ρ for higher α values.

One would expect the follower's profits to increase as its ability to improve the new product technology increases (i.e., x increases). However, why would the increase in x cause the pioneer's profits to increase? As x increases, two things happen. On one hand, the consumption utility of y_2 increases. On the other hand, the reference point for attribute B shifts upward. Recall that in equilibrium the follower adopts a revolutionary strategy, the pioneer sells y_1 to the conservative segment, and the follower sells y_2 to the nonconservative segment. As the reference point for attribute B shifts upward, the loss that the conservative consumers incur on attribute B when they stay with y_0 increases, which in turn allows the pioneer's price and hence profits to increase.

For small α values, the follower does not find it profitable to serve to the conservative segment at all; thus, in equilibrium the pioneer can charge monopoly price $price^{\text{rev}}_{y_1} = \gamma\rho(b+x)/(3(1+\gamma))$ to the conservative consumers, which is equal to the price premium y_1 enjoys over y_0 among those consumers. Because this premium increases as γ increases and/or ρ increases, and the follower's price increases in the pioneer's price, both firms' prices and profits increase with γ and ρ.

On the other hand, for higher α values, if the pioneer charges a monopoly price to the conservative segment, the follower will have an incentive to charge a low enough price for y_2 to steal the conservative consumers. Thus, in equilibrium the pioneer charges a low enough price to ensure that $price^{\text{rev}}_{y_1} + \rho x/(1+\gamma) \le (price^{\text{rev}}_{y_1} + x/(1+\gamma))(1-\alpha)$, i.e., $price^{\text{rev}}_{y_1} \le x(1-\alpha-\rho)/(\alpha(1+\gamma))$, to discourage the follower to compete for the conservative segment. Note that $x(1-\alpha-\rho)/(\alpha(1+\gamma))$ decreases as γ and/or ρ increase because the follower has a stronger incentive to compete for the conservative segment at higher values of γ and ρ. This happens because the conservative consumers find the new technology more attractive compared with the old one as γ and/or ρ increase. Therefore, the pioneer needs to charge an even lower price to be able to deter the follower to serve to the conservative segment as γ and/or ρ increase, and the follower needs to lower its price in turn to keep nonconservative consumers. Consequently, both the pioneer's and follower's prices and profits decrease as γ and/or ρ increase.

So far, we have assumed that the follower can improve the new technology either on attribute A dimension (i.e., pursue conservative strategy) or on attribute B dimension (i.e., pursue revolutionary strategy). In the following section, we relax this assumption and allow the follower to improve the new technology on both dimensions at the same time. In doing so, we investigate whether the impact of context-dependent preferences on firms' innovation strategy is robust so that withstanding its strong incentive to improve the new technology on the old performance dimension the follower would still prefer to pursue the revolutionary strategy.

5. The Follower Can Improve in Both Attribute A and Attribute B Dimensions

Let the follower choose one of following three strategies: (1) locate at $(0, b+x)$, (2) locate at (x, b), or (3) locate at $(x/2, b+x/2)$. We call the last strategy the middle-road strategy. We assume that if the follower pursues the middle-road strategy, the development (or R&D) cost is equal to D_2 and the unit manufacturing cost is zero.

We first check whether the follower ever prefers to pursue the middle-road strategy in the absence of context-dependent preferences. The proofs of the lemma and proposition in this section are provided in the online technical appendix, which also contains the details on consumers' utility functions.

Lemma 2. *In the absence of context-dependent preferences, the follower prefers to pursue the conservative strategy. The follower never prefers the revolutionary strategy to the middle-road strategy.*

The intuition for Lemma 2 is similar to that for Lemma 1. Basically, y_2^{cons} provides higher consumption utility to more consumers in the market than $y_2^{\text{middle-road}}$, which in turn provides higher consumption utility to more consumers than y_2^{rev}. Therefore, in the absence of context-dependent preferences, the follower would pursue the conservative strategy and never strictly prefer the revolutionary strategy over the middle-road strategy. But what happens when consumers exhibit context-dependent preferences?

Proposition 2. *There exists an $\underline{\alpha}$ such that when consumers exhibit context-dependent preferences, if $0 < x < a/2$ and $\underline{\alpha} < \alpha < \bar{\alpha}$ in equilibrium the follower prefers to pursue the revolutionary strategy.*

Proposition 2 shows that the impact of context-dependent preferences on firms' innovation strategy is so strong that even if the follower has the option of improving the new product technology both in the new performance dimension and in the old performance dimension, it still prefers to pursue the revolutionary strategy. We know from Proposition 1 why the follower prefers to pursue the revolutionary strategy rather than the conservative strategy. But why would the follower prefer the revolutionary strategy over the middle-road strategy withstanding its strong incentive to improve the new technology on the old performance dimension? On one hand, when the follower pursues the middle-road strategy rather than the revolutionary one, both the upward shift in the reference point for attribute B dimension and the downward shift in the reference point for attribute A dimension are smaller. For that reason, the price the pioneer can charge to the conservative consumers for y_1 is lower when the follower pursues the middle-road strategy than when it pursues the revolutionary strategy. This outcome causes the follower's price as well to decrease. On the other hand, since the reference point for attribute A is higher when the follower pursues the middle-road strategy than when the follower pursues the revolutionary strategy, the price premium the follower can charge for y_2 over y_1 to the nonconservative segment is higher because consumers would incur more loss in comparative utility on attribute A dimension if they choose y_1. This positive effect, unlike the aforementioned negative one, causes the follower's price to increase and dominates the negative one for small α values given that the conservative segment is not so important for the follower for small α values. However, as α increases (i.e., $\underline{\alpha} < \alpha$), the conservative segment becomes more important for the follower and hence the potential price competition between the follower and the pioneer to win over the conservative segment becomes more intense. In this case, the negative competitive effect of pursuing the middle-road strategy on the follower's price dominates the positive effect; as a result, the follower prefers the revolutionary strategy to the middle-road strategy. Obviously, for even higher α values (i.e., $\alpha > \bar{\alpha}$), as in Proposition 1, the follower prefers to pursue the conservative strategy because the conservative segment becomes too important to not serve in equilibrium by the follower.

In our basic model we assumed that a follower enters and decides whether to pursue the revolutionary or conservative strategy and investigated how the existence of context-dependent preferences affects the follower's new product strategy. However, one may wonder how the existence of context-dependent preferences affects the pioneer's decision about its innovation path when it is a monopolist. In particular, one may wonder whether and how (1) the context-dependent preferences of consumers affect a monopoly firm's innovation strategy and (2) its impact on a firm's innovation strategy differs in the case of monopoly versus duopoly competition. For that purpose, in the following section, we investigate the case in which the pioneer, rather than a follower, launches y_2 (i.e., the improved new technology product).

6. The Pioneer Firm Launches y_2

In the following section, we first characterize the pioneer's decision whether to pursue the conservative or revolutionary strategy in the absence of context-dependent preferences and then investigate how the pioneer's new product strategy changes when consumers' preferences are context dependent. As in the basic model, we assume that the development cost of y_2 is equal to D_2 and the manufacturing cost of y_2 is zero. To make a fair comparison with the case that the follower launches y_2, we assume that D_2 is small enough so that the pioneer always finds it profitable to develop y_2. The proofs of the lemma and proposition in this section are provided in the online technical appendix, which also contain the details on consumers' utility functions.

Lemma 3. *In the absence of context-dependent preferences, the pioneer prefers to pursue the conservative strategy if $\alpha > (1-\rho)b/((1-\rho)b+x)$ and it is indifferent between the two strategies otherwise.*

The intuition for Lemma 3 follows the same logic as in Lemmas 1 and 2. Conservative strategy is preferred when the firm sells to both segments because the conservative segment obtains higher utility from y_2^{cons} than from y_2^{rev}. When α is small, however, it becomes optimal for the firm to sell only to the nonconservative consumers who like the new technology more than the conservative consumers do. In this case, the firm is indifferent between the two strategies because the nonconservative consumers derive the same value from y_2^{cons} and y_2^{rev}.

The following proposition investigates whether and how the consideration of context-dependent consumer preferences affects a monopolist's innovation strategy.

Proposition 3. *When consumers' preferences are context dependent, under the same conditions as in Proposition 1, the pioneer prefers to pursue the conservative strategy for y_2. However, there exists a $\hat{\alpha}$ such that the pioneer strictly prefers to pursue the revolutionary strategy for y_2 if $a < x < ((1+\rho)/\rho)a$ and $0 < \alpha < \hat{\alpha}$.*

According to Proposition 3, even in case of monopoly, the existence of context-dependent preferences can significantly alter a firm's innovation strategy. Although the pioneer weakly prefers the conservative strategy in the absence of context-dependent preferences, it may strongly prefer to pursue the revolutionary strategy if consumers' preferences are context dependent. Therefore, Proposition 3 shows that (i) context-dependent preferences influence a firm's innovation strategy regardless of its being a monopolist or being in a duopoly, but (ii) the impact of context-dependent preferences on a firm's innovation strategy in the case of monopoly differs significantly from the case of duopoly. More specifically, context-dependent preferences have the opposite effect on the follower's and the pioneer's innovation strategies. Recall from Proposition 1 that when consumers' preferences are context dependent, the follower prefers to pursue the conservative strategy if $x > a/2$. However, the consideration of the context-dependent consumer preferences leads the pioneer to pursue the revolutionary strategy if $a < x < ((1+\rho)/\rho)a$ and $\alpha < \hat{\alpha}$. How can this happen? When the conservative segment's size is high (i.e., $\alpha > \hat{\alpha}$), it is not profitable for the pioneer to sell y_2 just to the nonconservative segment. Since the conservative segment values attribute B less for high α values, the pioneer does not prefer to pursue the revolutionary strategy. For low enough α values (i.e., $\alpha < \hat{\alpha}$), on the other hand, the pioneer would prefer to serve only to the nonconservative segment with y_2, and to avoid price competition between y_1 and y_2, it either would not offer y_1 or offer it at an unreasonably high price. The pioneer's decision whether or not offer y_1 also affects the reference points for attribute A and attribute B. For $a < x < ((1+\rho)/\rho)a$, if the pioneer offers y_1 at an unreasonably high price and pursues the revolutionary strategy, due to the shifts in reference points for attribute A and attribute B, the price premium that the nonconservative consumers are willing to pay for y_2 over y_0 reaches to its maximum value, which in turn encourages the pioneer to pursue the revolutionary strategy.[10]

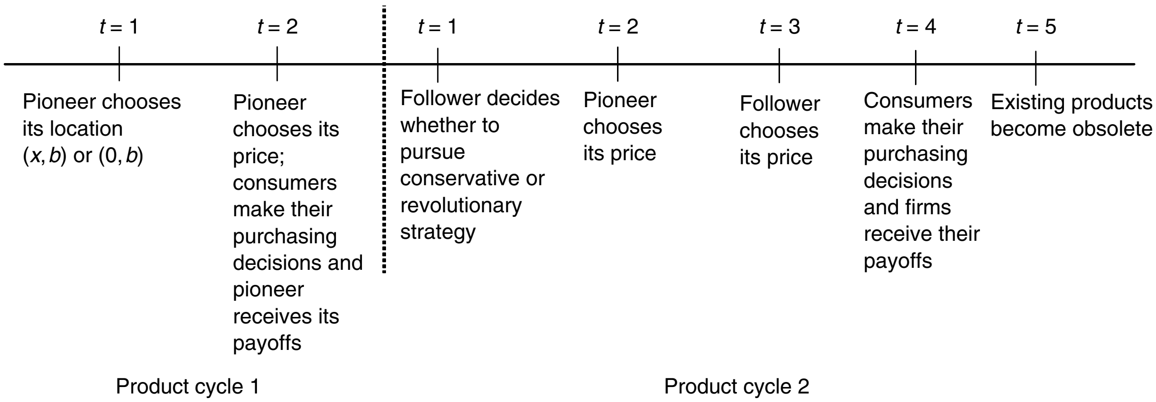
So far, we have conducted our analysis for a given location of the pioneer product based on the new technology (i.e., y_1) and only focus on the effect of context-dependent consumer preferences on the follower firm's innovation strategy. In other words, we did not allow the pioneer to choose the location for y_1 foreseeing the entry of the follower. In the following section, we relax this assumption and extend the game such that there will be two product development cycles. In the first cycle, the pioneer firm chooses its location. In doing so, our aim is to investigate (1) whether the result stated in Proposition 1 is robust and (2) whether and how context-dependent consumer preferences affect the innovation strategy of the pioneer firm of the new technology. Therefore, for this purpose we conduct our analysis under the conditions of Proposition 1 (i.e., for $0 < x < a/2$ and $0 < \alpha < \bar{\alpha}$).

7. Dynamic Game

In the first product cycle, let there be two options available for the pioneer firm at which to locate y_1, i.e., $(0, b)$ and (x, b). If the pioneer chooses to locate at (x, b), it needs to incur development cost of D_2 rather than D_1. As in the basic model, we assume that if the pioneer chooses to locate at (x, b), the manufacturing cost is zero. After the pioneer chooses its location and price, it sells as a monopoly for a period. In the second product cycle, at $t = 1$ the follower chooses where to locate y_2, at $t = 2$ the pioneer firm makes its pricing decision, at $t = 3$ the follower makes its pricing decision, and at $t = 4$ consumers make their purchasing decision and firms receive their payoffs. Finally, at $t = 5$ both y_1 and y_2 become obsolete. See Figure 5 for the extended timeline. If the pioneer firm chooses to locate at $(0, b)$, the follower can choose to locate either at (x, b) or at $(0, b + x)$. If the pioneer firm chooses to locate at (x, b), the follower can choose to locate

[10] Naturally, one can question whether a product as y_1 with no sales (or with minimal market share) can affect the reference points. In fact, there is an abundant behavioral evidence for a decoy such as a clearly dominated alternative increasing the choice probability of the dominating alternative in the choice set. More specifically, it has been experimentally shown that when an asymmetrically dominated alternative (i.e., dominated by at least one alternative in the set but is not dominated by at least one other) is added to a choice set, the share of the item that dominates increases (Simonson 1989, Huber et al. 1982). Furthermore, Simonson and Tversky (1992) experimentally show that even when an option that is unavailable for choice is presented, it creates compromise effect. These behavioral findings suggest that an option may affect consumers' preferences even if it has minimal or no market share.

Figure 5 **Extended Timeline**



either at $(2x, b)$ (i.e., pursue the conservative strategy) or at $(x, b+x)$ (i.e., pursue the revolutionary strategy).[11] In either case, the follower incurs a development cost of D_3 and manufacturing cost is zero. The discount factor is assumed to be 1 for simplicity.

In each product cycle, a set of consumers with a size of 1 enters the market to consider buying the products with new technology; α proportion of these consumers is conservative, whereas $(1-\alpha)$ proportion is nonconservative. In the product cycle she enters, each consumer buys one unit in the product category. Consumers leave the market at the end of each product cycle. The consumers' utility functions when the pioneer locates at (x, b) are provided in the appendix.

Lemma 4. *In the absence of context-dependent preferences, there exists a $\bar{D}_2$ such that for $D_2 < \bar{D}_2$ the pioneer prefers to locate at (x, b). When the pioneer locates at (x, b), the follower prefers to pursue the revolutionary strategy.*

Locating at (x, b) rather than $(0, b)$ increases the pioneer's profits in two ways. On one hand, the pioneer's monopoly profits in the first period are higher when it locates at (x, b) rather than at $(0, b)$. On the other hand, by locating at (x, b) rather than $(0, b)$, the pioneer leads the follower to pursue the revolutionary strategy rather than the conservative strategy[12] and as a result receives higher profits in the second cycle. We will call the former effect of locating at the technologically more advanced position the "direct benefit" and the latter effect the "strategic benefit." Thus, it is obvious that unless D_2 is too high, the pioneer prefers to locate at (x, b).

In the following proposition, we investigate whether the presence of context-dependent preferences encourages or discourages the pioneer to locate at (x, b) and why.

Proposition 4. *There exists a D_2^* such that when the consumers' preferences are context dependent, the pioneer firm prefers to locate at $(0, b)$ if $D_2^* < D_2 < \bar{D}_2$.*

We know from Lemma 4 that in the absence of context-dependent preferences, the pioneer prefers to locate at (x, b) if $D_2^* < D_2 < \bar{D}_2$. Proposition 4, however, shows that the presence of context-dependent preferences may lead the pioneer to locate at a technologically inferior location for strategic reasons (i.e., independent of any capability and cost considerations). The intuition behind this seemingly surprising outcome is as follows. With context-dependent preferences, consumers incur additional loss from higher prices compared to the reference prices. This reduces the price premiums that can be obtained by firms with new technologies. Consequently, the direct benefit of locating at (x, b) versus locating at $(0, b)$ decreases. In addition, the reduced direct benefit results in reduced relative benefit for the follower to pursue the revolutionary strategy in the (x, b) case versus in the $(0, b)$ case. Therefore, the follower becomes more likely to pursue the conservative strategy in the (x, b) case, which in turn also leads to reduced strategic benefit for the pioneer to locate at (x, b) in the first product cycle. As a result, the pioneer is less inclined to incur a high development cost to locate at a technologically advanced position when the preferences are context dependent.[13]

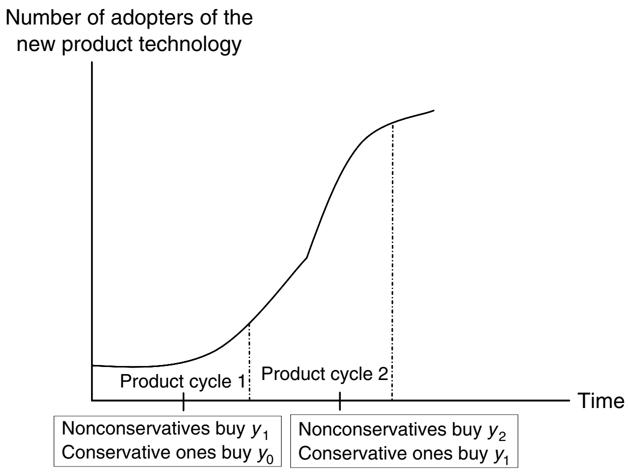
This result shows that the presence of context-dependent preferences can alter a firm's innovation

[11] We assume that it is too costly for the follower to improve the product by $2x$ at a time.

[12] This is because y_1 is able to enjoy a higher price premium over y_0 among the conservative consumers if it locates at (x, b) than if it locates at $(0, b)$. Consequently, this lessens the competition between the pioneer and the follower if the follower chooses the revolutionary strategy.

[13] The intuition discussed here also applies in other situations of innovation path choices by the pioneer in the first product cycle. For example, it may choose between $(0, b)$ and $(0, b+x)$, and the presence of the context-dependent preferences may also make the pioneer to be more likely to choose $(0, b)$.

Figure 6 **Diffusion of the New Product Technology**



strategy regardless of whether the firm is the pioneer or the follower of the new technology. In fact, once the context-dependent consumer preferences are considered, both the pioneer and the follower firms of the new technology become less likely to invest in the improvement of the key product attribute shared with the old technology.

Note that if $x < a/2$, $\alpha < \bar{\alpha}$, and $D_2^* < D_2 < \bar{D}_2$ in equilibrium the pioneer locates at $(0, b)$ and in the first product cycle sells y_1 only to the nonconservative segment. In the second cycle, the follower locates at $(0, b+x)$ and sells y_2 to the nonconservative segment, and the pioneer sells y_1 to the conservative segment. Figure 6 depicts this equilibrium outcome. As seen in Figure 6, the equilibrium outcome in Proposition 4 is also in line with the diffusion process of new products and technologies (Bass 1969) so that not all consumers buy the most technologically advanced product in the market. Only the nonconservative segment, which is analogous to early adopters, buys the technologically most advanced product in each product cycle.

8. Conclusion

In this paper, we propose a game-theoretical model to examine the pattern of technology evolution. We incorporate consumer's context-dependent preference into the model and also allow for consumer heterogeneity in their preferences toward the new product attribute introduced by the new technology. Our analysis shows that, controlling for the cost of innovation, a follower on new technology may prefer to improve on performance of the product attribute unique to the new technology instead of catching up on the lagged performance on the product attribute shared by both old and new technologies. Obviously there may be many reasons, such as technical incapability and cost (i.e., it may be impossible or too costly to improve the new technology on the established performance dimension), for firms to pursue the revolutionary strategy. However, we show that the context-dependent preferences of consumers can also be an important driver for firms' decision to pursue the revolutionary strategy even in the absence of other factors such as technical feasibility and cost difference. Because of context-dependent consumer preferences, once the follower adopts the revolutionary strategy, conservative consumers who exhibit stronger preference to the old product performance dimension may switch from buying products based on the old technology to buying products made by the pioneer firm of the new technology. As a result, the pioneer and the follower of the new technology focus on serving different consumer segments in equilibrium. This mitigates the price competition between the pioneer and the follower and thus gives the follower an incentive to choose the revolutionary strategy. To further induce the follower to adopt the revolutionary strategy, the pioneer may optimally choose a technologically less advanced product with the new product attribute when such a decision is made endogenously.

Our results offer several important implications to the evolution of new technology and insights for managers to make optimal technology selection early in product development. First, it suggests that a pioneer firm of a new technology may have an incentive to enter the market even with poor performance on both existing and new product performance dimensions. For example, the first generation of digital cameras had poor performance on both resolution (the existing dimension) and convenience of photo transferring to personal computers (the new dimension). Our analysis shows that the launch of those digital cameras is justifiable because it serves the purpose of inviting further innovation on the new performance dimension, which in turn improves the profitability of the pioneer. Second, our results show that after the introduction of a new technology and the new product performance dimension associated with it, a follower may focus on improving the performance on the new production dimension instead of closing the gap between the new technology and the old technology on the performance dimensions shared by them. This implies that the progress on a performance dimension shared by all technologies may be stagnant for a considerably long period before we see a jump in performance along this dimension. Sood and Tellis (2005) provide empirical support to our result by showing that the technological evolution of 9 out of 14 technologies from desktop memory, display monitors, desktop printers, and data transfer markets follows a step function, with periods of stagnant performance improvement interrupted by discontinuous jumps on the key performance dimension shared by all technologies in the category. Third, our results suggest the importance of understanding the context-dependent preferences of consumers. We show that firms' optimal strategies on product innovation can be very different once the context-dependent preferences of consumers are considered. Therefore, careful marketing research should be conducted before new product launch not only to understand consumers' preference given the currently available choice set but also to predict how their preference may change with the future innovations in the product category.

Even though our results are qualitatively robust with regard to different assumptions of reference points used by consumers, quantitatively the results on firms' prices and profits are certainly dependent on the choices of reference points. Future research may examine the formation of reference points in more detail. Most interestingly, the possibility of firms to strategically influence the way that references points are constructed by consumers can be explored. Finally, future research may test the implications of our results with experimental or empirical studies.

Appendix

Notation

Let $U_i^{s,l}$ denote the utility consumer i derives under strategy s of the follower from product l and let $price_l^s$ denote price of product l under strategy s of the follower, where $i = \{c, nc\}$, $s = \{\text{cons}, \text{rev}\}$, and $l = \{y_0, y_1, y_2\}$.

Proof of Lemma 1. First note that consumers make their choices based on utility maximization. Denote $q_i^{s,l}$ as the demand of product l from consumer segment i derived under strategy s of the follower. Based on the utility expressions in Table A.1,

$$q_c^{\text{cons}, y_1} = I\big(price_{y_1}^{\text{cons}} < \min(0, price_{y_2}^{\text{cons}} - x)\big),$$
$$q_c^{\text{rev}, y_1} = I\big(price_{y_1}^{\text{rev}} < \min(0, price_{y2}^{\text{rev}} - \rho x)\big),$$
$$q_c^{\text{cons}, y_2} = I\big(price_{y_2}^{\text{cons}} \le \min(x, x + price_{y_1}^{\text{cons}})\big),$$
$$q_c^{\text{rev}, y_2} = I\big(price_{y_2}^{\text{rev}} \le \min(\rho x, \rho x + price_{y_1}^{\text{rev}})\big),$$

Table A.1 **Consumer Utilities When Preferences Are Not Context Dependent**

Follower's strategy	
Conservative strategy	Revolutionary strategy
Conservative segment	
$U_c^{\text{cons}, y_0} = a$	$U_c^{\text{rev}, y_0} = a$
$U_c^{\text{cons}, y_1} = \rho b - price_{y_1}^{\text{cons}}$	$U_c^{\text{rev}, y_1} = \rho b - price_{y_1}^{\text{rev}}$
$U_c^{\text{cons}, y_2} = \rho b + x - price_{y_2}^{\text{cons}}$	$U_c^{\text{rev}, y_2} = \rho(b + x) - price_{y_2}^{\text{rev}}$
Nonconservative segment	
$U_{nc}^{\text{cons}, y_0} = a$	$U_{nc}^{\text{rev}, y_0} = a$
$U_{nc}^{\text{cons}, y_1} = b - price_{y_1}^{\text{cons}}$	$U_{nc}^{\text{rev}, y_1} = b - price_{y_1}^{\text{rev}}$
$U_{nc}^{\text{cons}, y_2} = b + x - price_{y_2}^{\text{cons}}$	$U_{nc}^{\text{rev}, y_2} = b + x - price_{y_2}^{\text{rev}}$

$$q_{nc}^{s, y_1} = I\big(price_{y_1}^{s} < \min(b - a, price_{y_2}^{s} - x)\big),$$
$$q_{nc}^{s, y_2} = I\big(price_{y_2}^{s} \le \min(b - a + x, x + price_{y_1}^{s})\big),$$

and

$$q_i^{s, y_0} = 1 - q_i^{s, y_1} - q_i^{s, y_2},$$

where $I(expression) = 1$ if the expression in $I(\cdot)$ holds and $I(expression) = 0$ otherwise.

The follower pursues the conservative strategy: Based on the utility given in Table A.1 and the resultant demand function, the demand for y_1 is 0 if $price_{y_1}^{\text{cons}} \ge price_{y_2}^{\text{con}} - x$ and the demand for y_2 is 0 if $price_{y_2}^{\text{cons}} > price_{y_1}^{\text{con}} + x$. Thus, it is easy to see that $price_{y_1}^{\text{cons}} = 0$ and $price_{y_2}^{\text{cons}} = x$ in equilibrium. Therefore, the follower obtains all consumers in equilibrium under conservative strategy and its profit is $x - D_2$.

The follower pursues the revolutionary strategy: Based on the utility given in Table A.1 and the resultant demand function, the demand for y_1 from the conservative consumers is zero for any $price_{y_1}^{\text{rev}} \ge 0$. The optimal price of y_2 is $price_{y_2}^{\text{rev}} = \rho x$ if the follower wants to sell to all consumers and $price_{y_2}^{\text{rev}} = price_{y_1}^{\text{rev}} + x$ if it wants to sell to the nonconservative segment only. In equilibrium the optimal $price_{y_1}^{\text{rev}}$ is 0 because only the case where the follower only sells to the nonconservative segment matters to the pioneer's price decision. Therefore, if $\alpha > 1 - \rho$ (i.e., $\rho x > x(1 - \alpha)$), then $price_{y_2}^{\text{rev}} = \rho x$ in equilibrium and the follower's profit is $x - D_2$; if $\alpha \le 1 - \rho$, then $price_{y_2}^{\text{rev}} = x$ in equilibrium and the follower's profit is $(1 - \alpha)x - D_2$.

Comparing the follower's profits under the conservative and the revolutionary strategy, it is obvious that the follower will pursue the conservative strategy in equilibrium. □

Proof of Proposition 1. From Tables A.2 and A.3 and consumer utility maximization, we can obtain $q_i^{s,l}$ as function of prices from $q_i^{s, y_1} = I(U_i^{s, y_1} > \max(U_i^{s, y_0}, U_i^{s, y_2}))$, $q_i^{s, y_2} = I(U_i^{s, y_2} \ge \max(U_i^{s, y_0}, U_i^{s, y_1}))$, and $q_i^{s, y_0} = 1 - q_i^{s, y_1} - q_i^{s, y_2}$ similar to what we did in the benchmark case where there is no context-dependent preferences.

Under the Conservative Strategy.

Case (i): $x < \frac{a}{2}$. From Table A.2, $price_{y_2}^{\text{cons}} \le price_{y_1}^{\text{con}} + x \rightarrow U_c^{\text{cons}, y_2} - U_c^{\text{cons}, y_1} = U_{nc}^{\text{cons}, y_2} - U_{nc}^{\text{cons}, y_1} \ge 0$. Therefore, the follower will always make $price_{y_2}^{\text{cons}} \le price_{y_1}^{\text{con}} + x$ in equilibrium, and consequently $price_{y_1}^{\text{cons}} = 0$ in equilibrium. Because $U_c^{\text{cons}, y_2} > U_c^{\text{cons}, y_0}$ and $U_{nc}^{\text{cons}, y_2} > U_{nc}^{\text{cons}, y_0}$ when $price_{y_2}^{\text{cons}} \le x$, we have $price_{y_2}^{\text{cons}} = x$ in equilibrium. The follower would sell y_2 to all the consumers, and its profits would be $\pi_{y_2}^{\text{cons}} = x - D_2$.

Case (ii): $\frac{a}{2} \le x < a$. From Table A.2, $price_{y_2}^{\text{cons}} \le price_{y_1}^{\text{cons}} + \frac{x(3+\gamma)+\gamma a}{3(1+\gamma)} \rightarrow U_c^{\text{cons}, y_2} - U_c^{\text{cons}, y_1} = U_{nc}^{\text{cons}, y_2} - U_{nc}^{\text{cons}, y_1} \ge 0$. Therefore, the follower will always make $price_{y_2}^{\text{cons}} \le price_{y_1}^{\text{con}} + \frac{x(3+\gamma)+\gamma a}{3(1+\gamma)}$ in equilibrium, and consequently $price_{y_1}^{\text{cons}} = 0$ in equilibrium. Because $U_c^{\text{cons}, y_2} > U_c^{\text{cons}, y_0}$ and $U_{nc}^{\text{cons}, y_2} > U_{nc}^{\text{cons}, y_0}$ when $price_{y_2}^{\text{cons}} \le \frac{x(3+\gamma)+\gamma a}{3(1+\gamma)}$, we have $price_{y_2}^{\text{cons}} = \frac{x(3+\gamma)+\gamma a}{3(1+\gamma)}$ in equilibrium. The follower would sell y_2 to all the consumers and its profits would be $\pi_{y_2}^{\text{cons}} = \frac{x(3+\gamma)+\gamma a}{3(1+\gamma)} - D_2$.

Case (iii): $a \le x < 2a$. From Table A.2, $price_{y_2}^{\text{cons}} \le price_{y_1}^{\text{con}} + \frac{x(3+\gamma)+\gamma a}{3(1+\gamma)} \rightarrow U_c^{\text{cons}, y_2} - U_c^{\text{cons}, y_1} = U_{nc}^{\text{cons}, y_2} - U_{nc}^{\text{cons}, y_1} \ge 0$. Therefore, the follower will always make $price_{y_2}^{\text{cons}} \le price_{y_1}^{\text{con}} + \frac{x(3+\gamma)+\gamma a}{3(1+\gamma)}$ in equilibrium, and consequently $price_{y_1}^{\text{cons}} = 0$ in

Table A.2 Consumer Utilities Under Conservative Strategy When Consumers' Preferences Are Context Dependent

	Consumption valuation	Comparative valuation
	Conservative segment	
$U_c^{\text{cons}, y_0} =$	a	$-\rho\gamma \frac{2b}{3}$ if $x < 2a$
$U_c^{\text{cons}, y_0} =$	a	$-\rho\gamma \frac{2b}{3} - \gamma \frac{(x-2a)}{3}$ if $x > 2a$
$U_c^{\text{cons}, y_1} =$	$\rho b - price_{y_1}^{\text{cons}}$	$-\gamma \frac{(a+x)}{3} - \gamma\, price_{y_1}^{\text{cons}}$
$U_c^{\text{cons}, y_2} =$	$\rho b + x - price_{y_2}^{\text{cons}}$	$-\gamma \frac{(a-2x)}{3} - \gamma\, price_{y_2}^{\text{cons}}$ if $\frac{a}{2} > x$
$U_c^{\text{cons}, y_2} =$	$\rho b + x - price_{y_2}^{\text{cons}}$	$-\gamma\, price_{y_2}^{\text{cons}}$ if $\frac{a}{2} < x$
	Nonconservative segment	
$U_{nc}^{\text{cons}, y_0} =$	a	$-\gamma \frac{2b}{3}$ if $x < 2a$
$U_{nc}^{\text{cons}, y_0} =$	a	$-\gamma \frac{2b}{3} - \gamma \frac{(x-2a)}{3}$ if $x > 2a$
$U_{nc}^{\text{cons}, y_1} =$	$b - price_{y_1}^{\text{cons}}$	$-\gamma \frac{(a+x)}{3} - \gamma\, price_{y_1}^{\text{cons}}$
$U_{nc}^{\text{cons}, y_2} =$	$b + x - price_{y_2}^{\text{cons}}$	$-\gamma \frac{(a-2x)}{3} - \gamma\, price_{y_2}^{\text{cons}}$ if $\frac{a}{2} > x$
$U_{nc}^{\text{cons}, y_2} =$	$b + x - price_{y_2}^{\text{cons}}$	$-\gamma price_{y_2}^{\text{cons}}$ if $\frac{a}{2} < x$

equilibrium. Because $U_{nc}^{\text{cons}, y_2} > U_{nc}^{\text{cons}, y_0}$ when $price_{y_2}^{\text{cons}} \le \frac{x(3+\gamma)+\gamma a}{3(1+\gamma)}$ and $U_c^{\text{cons}, y_2} \ge U_c^{\text{cons}, y_0} \to price_{y_2}^{\text{cons}} \le \frac{3x+2\gamma a}{3(1+\gamma)} < \frac{x(3+\gamma)+\gamma a}{3(1+\gamma)}$, in equilibrium $price_{y_2}^{\text{cons}} = \frac{x(3+\gamma)+\gamma a}{3(1+\gamma)}$ if $\alpha < \frac{(x-a)\gamma}{x(3+\gamma)+\gamma a}$ (which implies $\frac{3x+2\gamma a}{3(1+\gamma)} < (1-\alpha)\frac{x(3+\gamma)+\gamma a}{3(1+\gamma)}$) and $price_{y_2}^{\text{cons}} = \frac{3x+2\gamma a}{3(1+\gamma)}$ otherwise. If $\alpha < \frac{(x-a)\gamma}{x(3+\gamma)+\gamma a}$, then the follower sells y_2 only to the nonconservative segment and $\pi_{y_2}^{\text{cons}} = \frac{x(3+\gamma)+\gamma a}{3(1+\gamma)}(1-\alpha) - D_2$. If $\alpha > \frac{(x-a)\gamma}{x(3+\gamma)+\gamma a}$, then the follower sells y_2 to all the consumers and $\pi_{y_2}^{\text{cons}} = \frac{3x+2\gamma a}{3(1+\gamma)} - D_2$.

Case (iv): $2a \le x$. From Table A.2, $price_{y_2}^{\text{cons}} \le price_{y_1}^{\text{con}} + \frac{x(3+\gamma)+\gamma a}{3(1+\gamma)} \to U_c^{\text{cons}, y_2} - U_c^{\text{cons}, y_1} = U_{nc}^{\text{cons}, y_2} - U_{nc}^{\text{cons}, y_1} \ge 0$. Therefore, the follower will always make $price_{y_2}^{\text{cons}} \le price_{y_1}^{\text{con}} + \frac{x(3+\gamma)+\gamma a}{3(1+\gamma)}$ in equilibrium, and consequently $price_{y_1}^{\text{cons}} = 0$ in equilibrium. Because $U_{nc}^{\text{cons}, y_2} > U_{nc}^{\text{cons}, y_0}$ when $price_{y_2}^{\text{cons}} \le \frac{x(3+\gamma)+\gamma a}{3(1+\gamma)}$ and $U_c^{\text{cons}, y_2} \ge U_c^{\text{cons}, y_0} \to price_{y_2}^{\text{cons}} \le \frac{x(3+\gamma)}{3(1+\gamma)} < \frac{x(3+\gamma)+\gamma a}{3(1+\gamma)}$, in equilibrium $price_{y_2}^{\text{cons}} = \frac{x(3+\gamma)+\rho\gamma b}{3(1+\gamma)}$ if $\alpha < \frac{\gamma a}{x(3+\gamma)+\gamma a}$ (which implies $\frac{x(3+\gamma)}{3(1+\gamma)} < (1-\alpha)\frac{x(3+\gamma)+\gamma a}{3(1+\gamma)}$) and $price_{y_2}^{\text{cons}} = \frac{x(3+\gamma)}{3(1+\gamma)}$ otherwise. If $\alpha < \frac{\gamma a}{x(3+\gamma)+\gamma a}$, then the follower sells y_2 only to the nonconservative segment and $\pi_{y_2}^{\text{cons}} = \frac{x(3+\gamma)+\gamma a}{3(1+\gamma)}(1-\alpha) - D_2$. If $\alpha > \frac{\gamma a}{x(3+\gamma)+\gamma a}$, then the follower sells y_2 to all the consumers and $\pi_{y_2}^{\text{cons}} = \frac{x(3+\gamma)}{3(1+\gamma)} - D_2$.

Under the Revolutionary Strategy.

Case (i): $x < b$. From Table A.3, $price_{y_2}^{\text{rev}} \le price_{y_1}^{\text{rev}} + \frac{\rho x}{(1+\gamma)} \to U_c^{\text{rev}, y_2} - U_c^{\text{rev}, y_1} \ge 0$ and $price_{y_2}^{\text{rev}} \le price_{y_1}^{\text{rev}} + \frac{x}{(1+\gamma)} \to U_{nc}^{\text{rev}, y_2} - U_{nc}^{\text{rev}, y_1} \ge 0$. If $(price_{y_1}^{\text{rev}} + \frac{\rho x}{(1+\gamma)}) > (price_{y_1}^{\text{rev}} + \frac{x}{(1+\gamma)})(1-\alpha)$, which implies $price_{y_1}^{\text{rev}} > \frac{x(1-\alpha-\rho)}{\alpha(1+\gamma)}$, the follower prefers to sell to all consumers. In such case, $price_{y_1}^{\text{rev}} = 0$ in equilibrium as the pioneer would be as competitive as possible. If $\alpha > 1-\rho$, $price_{y_1}^{\text{rev}} > \frac{x(1-\alpha-\rho)}{\alpha(1+\gamma)}$ always holds so that $price_{y_1}^{\text{rev}} = 0$, $price_{y_2}^{\text{rev}} = \frac{\rho x}{(1+\gamma)}$ and $\pi_{y_2}^{\text{rev}} = \frac{\rho x}{(1+\gamma)} - D_2$. If $\alpha \le 1-\rho$ and $U_c^{\text{rev}, y_1} - U_c^{\text{rev}, y_0} \ge 0$ at $price_{y_1}^{\text{rev}} = \frac{x(1-\alpha-\rho)}{\alpha(1+\gamma)}$, which implies $\frac{3x(1-\rho)}{\rho\gamma b + x(3+\rho\gamma)} \le \alpha \le 1-\rho$, then the pioneer sells to the conservative segment and the follower sells to the nonconservative segment with $price_{y_1}^{\text{rev}} = \frac{x(1-\alpha-\rho)}{\alpha(1+\gamma)}$ and $price_{y_2}^{\text{rev}} = price_{y_1}^{\text{rev}} + \frac{x}{(1+\gamma)} = \frac{x(1-\rho)}{\alpha(1+\gamma)}$. In this case, $\pi_{y_1}^{\text{rev}} = \frac{x(1-\alpha-\rho)}{(1+\gamma)}$ and $\pi_{y_2}^{\text{rev}} = \frac{x(1-\rho)}{\alpha(1+\gamma)}(1-\alpha) - D_2$.

Table A.3 Consumer Utilities Under Revolutionary Strategy When Consumers' Preferences Are Context Dependent

	Consumption valuation	Comparative valuation
	Conservative segment	
$U_c^{\text{rev}, y_0} =$	a	$-\rho\gamma \frac{(2b+x)}{3}$
$U_c^{\text{rev}, y_1} =$	$\rho b - price_{y_1}^{\text{rev}}$	$-\gamma \frac{a}{3} - \gamma\, price_{y_1}^{\text{rev}}$ if $x < b$
$U_c^{\text{rev}, y_1} =$	$\rho b - price_{y_1}^{\text{rev}}$	$-\gamma \frac{a}{3} - \rho\gamma \frac{(x-b)}{3} - \gamma\, price_{y_1}^{\text{rev}}$ if $x > b$
$U_c^{\text{rev}, y_2} =$	$\rho(b+x) - price_{y_2}^{\text{rev}}$	$-\gamma \frac{a}{3} - \gamma\, price_{y_2}^{\text{rev}}$
	Nonconservative segment	
$U_{nc}^{\text{rev}, y_0} =$	a	$-\gamma \frac{(2b+x)}{3}$
$U_{nc}^{\text{rev}, y_1} =$	$b - price_{y_1}^{\text{rev}}$	$-\gamma \frac{a}{3} - \gamma\, price_{y_1}^{\text{rev}}$ if $x < b$
$U_{nc}^{\text{rev}, y_1} =$	$b - price_{y_1}^{\text{rev}}$	$-\gamma \frac{a}{3} - \gamma \frac{(x-b)}{3} - \gamma\, price_{y_1}^{\text{rev}}$ if $x > b$
$U_{nc}^{\text{rev}, y_2} =$	$b + x - price_{y_2}^{\text{rev}}$	$-\gamma \frac{a}{3} - \gamma\, price_{y_2}^{\text{rev}}$

If $\alpha \le 1-\rho$ and $U_c^{\text{rev}, y_1} - U_c^{\text{rev}, y_0} < 0$ at $price_{y_1}^{\text{rev}} = \frac{x(1-\alpha-\rho)}{\alpha(1+\gamma)}$, which implies $\alpha < \frac{3x(1-\rho)}{\rho\gamma b + x(3+\rho\gamma)}$ because $U_c^{\text{rev}, y_1} - U_c^{\text{rev}, y_0} \ge 0 \to price_{y_1}^{\text{rev}} \le \frac{\rho\gamma(b+x)}{3(1+\gamma)} < \frac{x(1-\alpha-\rho)}{\alpha(1+\gamma)}$, in equilibrium the pioneer sells to the conservative segment and the follower sells to the nonconservative segment with $price_{y_1}^{\text{rev}} = \frac{\rho\gamma(b+x)}{3(1+\gamma)}$, $price_{y_2}^{\text{rev}} = price_{y_1}^{\text{rev}} + \frac{x}{(1+\gamma)} = \frac{\rho\gamma b + x(3+\rho\gamma)}{3(1+\gamma)}$. In this case, $\pi_{y_1}^{\text{rev}} = \frac{\rho\gamma(b+x)}{3(1+\gamma)}\alpha$ and $\pi_{y_2}^{\text{rev}} = \frac{\rho\gamma b + x(3+\rho\gamma)}{3(1+\gamma)}(1-\alpha) - D_2$.

Case (ii): $x \ge b$. From Table A.3,

$$price_{y_2}^{\text{rev}} \le price_{y_1}^{\text{rev}} + \frac{\rho(3x+\gamma(x-b))}{3(1+\gamma)} \to U_c^{\text{rev}, y_2} - U_c^{\text{rev}, y_1} \ge 0$$

and

$$price_{y_2}^{\text{rev}} \le price_{y_1}^{\text{rev}} + \frac{(3x+\gamma(x-b))}{3(1+\gamma)} \to U_{nc}^{\text{rev}, y_2} - U_{nc}^{\text{rev}, y_1} \ge 0.$$

If $(price_{y_1}^{\text{rev}} + \frac{\rho(3x+\gamma(x-b))}{3(1+\gamma)}) > (price_{y_1}^{\text{rev}} + \frac{(3x+\gamma(x-b))}{3(1+\gamma)})(1-\alpha)$, which implies $price_{y_1}^{\text{rev}} > \frac{(3x+\gamma(x-b))(1-\alpha-\rho)}{3\alpha(1+\gamma)}$, the follower prefers to sell to all consumers. In such case, $price_{y_1}^{\text{rev}} = 0$ in equilibrium as the pioneer would be as competitive as possible. If $\alpha > 1-\rho$, $price_{y_1}^{\text{rev}} > \frac{(3x+\gamma(x-b))(1-\alpha-\rho)}{3\alpha(1+\gamma)}$ always holds so that $price_{y_1}^{\text{rev}} = 0$, $price_{y_2}^{\text{rev}} = \frac{\rho(3x+\gamma(x-b))}{3(1+\gamma)}$ and $\pi_{y_2}^{\text{rev}} = \frac{\rho(3x+\gamma(x-b))}{3(1+\gamma)} - D_2$. If $\alpha \le 1-\rho$ and $U_c^{\text{rev}, y_1} - U_c^{\text{rev}, y_0} \ge 0$ at $price_{y_1}^{\text{rev}} = \frac{(3x+\gamma(x-b))(1-\alpha-\rho)}{3\alpha(1+\gamma)}$, which implies $\frac{(3x+\gamma(x-b))(1-\rho)}{3x+\gamma(x-b)+2\rho\gamma b} \le \alpha \le 1-\rho$, then the pioneer sells to the conservative segment and the follower sells to the nonconservative segment with $price_{y_1}^{\text{rev}} = \frac{(3x+\gamma(x-b))(1-\alpha-\rho)}{3\alpha(1+\gamma)}$ and $price_{y_2}^{\text{rev}} = price_{y_1}^{\text{rev}} + \frac{(3x+\gamma(x-b))}{3(1+\gamma)} = \frac{(3x+\gamma(x-b))(1-\rho)}{3\alpha(1+\gamma)}$. In this case, $\pi_{y_1}^{\text{rev}} = \frac{(3x+\gamma(x-b))(1-\alpha-\rho)}{3(1+\gamma)}$ and $\pi_{y_2}^{\text{rev}} = \frac{(3x+\gamma(x-b))(1-\rho)}{3\alpha(1+\gamma)}(1-\alpha) - D_2$. If $\alpha \le 1-\rho$ and $U_c^{\text{rev}, y_1} - U_c^{\text{rev}, y_0} < 0$ at $price_{y_1}^{\text{rev}} = \frac{(3x+\gamma(x-b))(1-\alpha-\rho)}{3\alpha(1+\gamma)}$, which implies $\alpha < \frac{(3x+\gamma(x-b))(1-\rho)}{3x+\gamma(x-b)+2\rho\gamma b}$ because

$$U_c^{\text{rev}, y_1} - U_c^{\text{rev}, y_0} \ge 0 \to price_{y_1}^{\text{rev}} \le \frac{2\rho\gamma b}{3(1+\gamma)} < \frac{(3x+\gamma(x-b))(1-\alpha-\rho)}{3\alpha(1+\gamma)},$$

in equilibrium the pioneer sells to the conservative segment and the follower sells to the nonconservative segment with $price^{\text{rev}}_{y_1} = \frac{2\rho\gamma b}{3(1+\gamma)}$, $price^{\text{rev}}_{y_2} = price^{\text{rev}}_{y_1} + \frac{(3x+\gamma(x-b))}{3(1+\gamma)} = \frac{b\gamma(2\rho-1)+x(3+\gamma)}{3(1+\gamma)}$. In this case, $\pi^{\text{rev}}_{y_1} = \frac{2\rho\gamma b}{3(1+\gamma)}\alpha$ and $\pi^{\text{rev}}_{y_2} = \frac{b\gamma(2\rho-1)+x(3+\gamma)}{3(1+\gamma)}(1-\alpha) - D_2$.

Comparing the conservative strategy and revolutionary strategy. By comparing the follower's profits under the conservative strategy and revolutionary strategy, one can see that $\pi^{\text{rev}}_{y_2} > \pi^{\text{cons}}_{y_2}$ if $0 < x < \frac{a}{2}$ and

$$0 < \alpha < \min\left\{\frac{3x(1-\rho)}{\rho\gamma b + x(3+\rho\gamma)}, \frac{\rho\gamma b - x\gamma(3-\rho)}{\rho\gamma b + x(3+\rho\gamma)}\right\}$$

or if $0 < x < \frac{a}{2}$ and $\frac{3x(1-\rho)}{\rho\gamma b+x(3+\rho\gamma)} < \alpha < \frac{1-\rho}{2+\gamma-\rho}$.

Note that

$$\frac{3x(1-\rho)}{\rho\gamma b + x(3+\rho\gamma)} < \frac{1-\rho}{2+\gamma-\rho} \quad \text{if } x < \frac{\rho\gamma b}{(3+3\gamma-3\rho-\rho\gamma)}$$

and

$$\frac{3x(1-\rho)}{\rho\gamma b+x(3+\rho\gamma)} < \frac{\rho\gamma b - x\gamma(3-\rho)}{\rho\gamma b+x(3+\rho\gamma)} \quad \text{if } x < \frac{\rho\gamma b}{(3+3\gamma-3\rho-\rho\gamma)}.$$

In addition, it is easy to see $\frac{\rho\gamma b}{(3+3\gamma-3\rho-\rho\gamma)} < \frac{a}{2}$ always holds. Thus, we can obtain the conditions for α as $0 < \alpha < \frac{1-\rho}{2+\gamma-\rho}$ (i.e., $\bar{\alpha} = \frac{1-\rho}{2+\gamma-\rho}$) if $x < \frac{\rho\gamma b}{(3+3\gamma-3\rho-\rho\gamma)}$ and $0 < \alpha < \frac{\rho\gamma b + x\rho\gamma - 3x\gamma}{\rho\gamma b + x\rho\gamma + 3x}$ (i.e., $\bar{\alpha} = \frac{\rho\gamma b+x\rho\gamma-3x\gamma}{\rho\gamma b+x\rho\gamma+3x}$) if $\frac{\rho\gamma b}{(3+3\gamma-3\rho-\rho\gamma)} \le x < \frac{a}{2}$. $\square$

Proof of Lemma 4. *The pioneer locates at* $(0, b)$ *in the first product cycle.* In this case, from the utility functions in Table A.1 and the corresponding demand functions, the pioneer sells y_1 only to the nonconservative segment in the first product cycle with equilibrium *price* equal to $(b-a)$ and equilibrium profits equal to $(b-a)(1-\alpha) - D_1$. Given our assumption that $0 < x < \frac{a}{2}$ and $0 < \alpha < \bar{\alpha}$, from Lemma 1, in the second product cycle the follower prefers to pursue the conservative strategy and the pioneer receives zero profit. Therefore, the total profits of the pioneer are $(b-a)(1-\alpha) - D_1$.

The pioneer locates at (x, b) *in the first product cycle.* In the first product cycle, $U_c^{y_1} - U_c^{y_0} = x - price_{y_1}$ and $U_{nc}^{y_1} - U_{nc}^{y_0} = b - a + x - price_{y_1}$. Therefore, the pioneer would either set its *price* equal to x and receive profits of $x - D_2$ or set its *price* equal to $b-a+x$ and receive profits of $(b-a+x)(1-\alpha) - D_2$. The former case is the equilibrium if $x > (b-a+x)(1-\alpha)$, i.e., $\alpha > \frac{b-a}{b-a+x}$, and the latter case is the equilibrium if otherwise.

In the second period, if the follower pursues the conservative strategy, then $U_c^{\text{cons}, y_2} - U_c^{\text{cons}, y_1} = U_{nc}^{\text{cons}, y_2} - U_{nc}^{\text{cons}, y_1} = x + price^{\text{cons}}_{y_1} - price^{\text{cons}}_{y_2}$. In this case, the equilibrium $price^{\text{cons}}_{y_1}$ would be equal to zero and $price^{\text{cons}}_{y_2}$ would be equal to x, with $\pi^{\text{cons}}_{y_1} = 0$ and $\pi^{\text{cons}}_{y_2} = x - D_3$.

If the follower pursues the revolutionary strategy, then

$$U_c^{\text{rev}, y_2} - U_c^{\text{rev}, y_1} = \rho x + price^{\text{rev}}_{y_1} - price^{\text{rev}}_{y_2}$$

and

$$U_{nc}^{\text{rev}, y_2} - U_{nc}^{\text{rev}, y_1} = x + price^{\text{rev}}_{y_1} - price^{\text{rev}}_{y_2}.$$

If $(price^{\text{rev}}_{y_1} + \rho x) \ge (price^{\text{rev}}_{y_1} + x)(1-\alpha)$, i.e., $price^{\text{rev}}_{y_1} \ge \frac{x(1-\alpha-\rho)}{\alpha}$, the follower will set $price^{\text{rev}}_{y_2} = price^{\text{rev}}_{y_1} + \rho x$ and sell to all consumers. Consequently, $price^{\text{rev}}_{y_1} = 0$ in this case at the equilibrium. Note that $\frac{x(1-\alpha-\rho)}{\alpha} \le 0$ if $\alpha \ge 1-\rho$. Therefore, if $\alpha \ge 1-\rho$, the equilibrium is $price^{\text{rev}}_{y_1} = 0$, $price^{\text{rev}}_{y_2} = \rho x$, $\pi^{\text{rev}}_{y_1} = 0$ and $\pi^{\text{rev}}_{y_2} = \rho x - D_3$.

Because $U_c^{\text{rev}, y_1} - U_c^{\text{rev}, y_0} = x - price^{\text{rev}}_{y_1}$, the maximum price of y_1 is x for it to sell to the conservative segment. Therefore, if $\alpha < 1-\rho$, in equilibrium $price^{\text{rev}}_{y_1} = \min(x, \frac{x(1-\alpha-\rho)}{\alpha})$. Hence, if $\alpha < 1-\rho$ and $\frac{x(1-\alpha-\rho)}{\alpha} \le x$ (i.e., $\frac{1-\rho}{2} \le \alpha < 1-\rho$)), then $price^{\text{rev}}_{y_1} = \frac{x(1-\alpha-\rho)}{\alpha}$, $price^{\text{rev}}_{y_2} = \frac{x(1-\alpha-\rho)}{\alpha} + x = \frac{x(1-\rho)}{\alpha}$, $\pi^{\text{rev}}_{y_1} = x(1-\alpha-\rho)$ and $\pi^{\text{rev}}_{y_2} = \frac{x(1-\rho)}{\alpha}(1-\alpha) - D_3$. If $\alpha < \frac{1-\rho}{2}$, then $price^{\text{rev}}_{y_1} = x$, $price^{\text{rev}}_{y_2} = x + x = 2x$, $\pi^{\text{rev}}_{y_1} = x\alpha$, and $\pi^{\text{rev}}_{y_2} = 2x(1-\alpha) - D_3$.

Comparing the follower's profits under the conservative strategy and under the revolutionary strategy, one can see that $\pi^{\text{rev}}_{y_2} > \pi^{\text{cons}}_{y_2}$ if (i) $\alpha < \frac{1-\rho}{2-\rho}$ and $\frac{1-\rho}{2} \le \alpha < 1-\rho$ or (ii) $\alpha < \frac{1}{2}$ and $\alpha < \frac{1-\rho}{2}$. It is easy to verify that (i) and (ii) can be combined to $\alpha < \frac{1-\rho}{2-\rho}$.

Recall that $\bar{\alpha} = \frac{1-\rho}{2+\gamma-\rho}$ if $x < \frac{\rho\gamma b}{(3+3\gamma-3\rho-\rho\gamma)}$ and $\bar{\alpha} = \frac{\rho\gamma b+x\rho\gamma-3x\gamma}{\rho\gamma b+x\rho\gamma+3x}$ otherwise. Obviously, $\alpha < \bar{\alpha} = \frac{1-\rho}{2+\gamma-\rho} \to \alpha < \frac{1-\rho}{2-\rho}$. Also,

$$\frac{\rho\gamma b + x\rho\gamma - 3x\gamma}{\rho\gamma b + x\rho\gamma + 3x} < \frac{1-\rho}{2-\rho} \to x < \frac{\rho\gamma b}{3+6\gamma-3\rho-4\rho\gamma},$$

which always holds when $x < \frac{\rho\gamma b}{3+3\gamma-3\rho-\rho\gamma}$. Thus, $\alpha < \bar{\alpha} = \frac{\rho\gamma b+x\rho\gamma-3x\gamma}{\rho\gamma b+x\rho\gamma+3x} \to a < \frac{1-\rho}{2-\rho}$ if $x < \frac{\rho\gamma b}{3+3\gamma-3\rho-\rho\gamma}$. Therefore, $\alpha < \frac{1-\rho}{2-\rho}$ always holds when $\alpha < \bar{\alpha}$, so that the follower always adopts the revolutionary strategy when $\alpha < \bar{\alpha}$.

Comparing the pioneer's total profits from positioning at $(0, b)$ *and at* (x, b) *in the first product cycle.* Because $x < \frac{a}{2}$ and $a < \frac{1-\rho}{2-\rho}$ implies that $\alpha > \frac{b-a}{b-a+x}$ cannot hold, from the above analysis, the pioneer's total profits are $\pi_{(0,b)} = (b-a)(1-\alpha) - D_1$; $\pi_{(x,b)} = (b-a+x)(1-\alpha) + x(1-\alpha-\rho) - D_2$ if $\frac{1-\rho}{2} \le \alpha < \frac{1-\rho}{2-\rho}$; $\pi_{(x,b)} = (b-a+x)(1-\alpha) + x\alpha - D_2$ if $\alpha < \frac{1-\rho}{2}$. Thus, $\pi_{(x,b)} > \pi_{(0,b)}$ implies that $D_2 < D_1 + x(2-2\alpha-\rho)$ if $\frac{1-\rho}{2} \le \alpha < \frac{1-\rho}{2-\rho}$ or $D_2 < D_1 + x$ if $\alpha < \frac{1-\rho}{2}$. Combining those conditions, we obtain that $\pi_{(x,b)} > \pi_{(0,b)}$ if $D_2 < \bar{D}_2 = D_1 + \min[x(2-2\alpha-\rho), x]$. $\square$

Proof of Proposition 4. *The first cycle profits of the pioneer if it locates at* $(0, b)$. In this case, the reference point for the old product attribute is $\frac{a}{2}$ and the reference point for the new product attribute is $\frac{b}{2}$. The utility functions would be as follows: $U_c^{y_0} = a - \rho\gamma\frac{b}{2}$, $U_c^{y_1} = \rho b - \gamma\frac{a}{2} - (1+\gamma)price_{y_1}$, $U_{nc}^{y_0} = a - \gamma\frac{b}{2}$, $U_{nc}^{y_1} = b - \gamma\frac{a}{2} - (1+\gamma)price_{y_1}$.

In this case, since the conservative segment is not willing to buy y_1 with positive price of y_1, the pioneer's equilibrium price is equal to $\frac{(b-a)(2+\gamma)}{2(1+\gamma)}$ (which solves $U_{nc}^{y_1} = U_{nc}^{y_0}$), and its profits are $\frac{(b-a)(2+\gamma)}{2(1+\gamma)}(1-\alpha) - D_1$.

The total profits of the pioneer if it locates at $(0, b)$. Recall from the proof of Proposition 1 that in the second cycle the pioneer's profits are equal to $\frac{\rho\gamma(b+x)}{3(1+\gamma)}\alpha$ for $x < \frac{a}{2}$ and $\alpha < \min\{\frac{3x(1-\rho)}{\rho\gamma b+x(3+\rho\gamma)}, \frac{\rho\gamma b-x\gamma(3-\rho)}{\rho\gamma b+x(3+\rho\gamma)}\}$ and equal to $\frac{x(1-\alpha-\rho)}{(1+\gamma)}$ for $x < \frac{a}{2}$ and $\frac{3x(1-\rho)}{\rho\gamma b+x(3+\rho\gamma)} < \alpha < \frac{1-\rho}{2+\gamma-\rho}$. Therefore, when the pioneer locates at $(0, b)$, its total profits are equal to $\frac{(b-a)(2+\gamma)}{2(1+\gamma)}(1-\alpha) + \frac{\rho\gamma(b+x)}{3(1+\gamma)}\alpha - D_1$ if $x < \frac{a}{2}$ and $\alpha < \min\{\frac{3x(1-\rho)}{\rho\gamma b+x(3+\rho\gamma)}, \frac{\rho\gamma b-x\gamma(3-\rho)}{\rho\gamma b+x(3+\rho\gamma)}\}$ and equal to $\frac{(b-a)(2+\gamma)}{2(1+\gamma)}(1-\alpha) + \frac{x(1-\alpha-\rho)}{(1+\gamma)} - D_1$ if $x < \frac{a}{2}$ and $\frac{3x(1-\rho)}{\rho\gamma b+x(3+\rho\gamma)} < \alpha < \frac{1-\rho}{2+\gamma-\rho}$.

The first cycle profits of the pioneer if it locates at (x, b). In this case, the reference point for the old product attribute is $\frac{a+x}{2}$ and the reference point for the new product attribute is $\frac{b}{2}$. The utility functions given $x < \frac{a}{2}$ would be as follows:

$$U_c^{y_0} = a - \rho\gamma\frac{b}{2}, \quad U_c^{y_1} = \rho b + x - \gamma\frac{(a-x)}{2} - (1+\gamma)price_{y_1},$$

$$U_{nc}^{y_0} = a - \gamma\frac{b}{2}, \quad U_{nc}^{y_1} = b + x - \gamma\frac{(a-x)}{2} - (1+\gamma)price_{y_1}.$$

If the pioneer charges $\frac{x(2+\gamma)}{2(1+\gamma)}$ for y_1 (which solves $U_c^{y_1} = U_c^{y_0}$), then it can serve to all the consumers and receive profits of $\frac{x(2+\gamma)}{2(1+\gamma)} - D_2$. However, if the pioneer charges $\frac{(b-a+x)(2+\gamma)}{2(1+\gamma)}$ for y_1 (which solves $U_{nc}^{y_1} = U_{nc}^{y_0}$), then it can sell y_1 only to nonconservative segment and receive profits of $\frac{(b-a+x)(2+\gamma)}{2(1+\gamma)}(1-\alpha) - D_2$. It is obvious that $\frac{(b-a+x)(2+\gamma)}{2(1+\gamma)}(1-\alpha) - D_2 > \frac{x(2+\gamma)}{2(1+\gamma)} - D_2$ implies that $\alpha < \frac{b-a}{b-a+x}$. As we show in the proof of Lemma 4, $\alpha < \bar{\alpha} \to \alpha < \frac{1-\rho}{2-\rho}$; $x < \frac{a}{2}$ and $\alpha < \frac{1-\rho}{2-\rho} \to \alpha < \frac{b-a}{b-a+x}$ always holds. Therefore, $\alpha < \frac{b-a}{b-a+x}$ always holds for $\alpha < \bar{\alpha}$ and $x < \frac{a}{2}$. Hence, the equilibrium profits of the pioneer in the first cycle are equal to $\frac{(b-a+x)(2+\gamma)}{2(1+\gamma)} \cdot (1-\alpha) - D_2$.

The second cycle profits if the pioneer locates at (x, b) *and the follower adopts conservative strategy.* In this case, the reference point for the old product attribute is $\frac{a+3x}{3}$ and the reference point for the new product attribute is $\frac{2b}{3}$. The utility functions would be as follows:

$$U_c^{\text{cons},\,y_0} = a - \rho\gamma\frac{2b}{3},$$

$$U_c^{\text{cons},\,y_1} = \rho b + x - \gamma\frac{a}{3} - (1+\gamma)price_{y_1}^{\text{cons}},$$

$$U_c^{\text{cons},\,y_2} = \rho b + 2x - \gamma\frac{a-3x}{3} - (1+\gamma)price_{y_2}^{\text{cons}} \quad \text{if } a \geq 3x,$$

$$U_c^{\text{cons},\,y_2} = \rho b + 2x - (1+\gamma)price_{y_2}^{\text{cons}} \quad \text{if } a < 3x,$$

$$U_{nc}^{\text{cons},\,y_0} = a - \gamma\frac{2b}{3},$$

$$U_{nc}^{\text{cons},\,y_1} = b + x - \gamma\frac{a}{3} - (1+\gamma)price_{y_1}^{\text{cons}},$$

$$U_{nc}^{\text{cons},\,y_2} = b + 2x - \gamma\frac{a-3x}{3} - (1+\gamma)price_{y_2}^{\text{cons}} \quad \text{if } a \geq 3x,$$

$$U_{nc}^{\text{cons},\,y_2} = b + 2x - (1+\gamma)price_{y_2}^{\text{cons}} \quad \text{if } a < 3x.$$

Therefore,

$$U_c^{\text{cons},\,y_2} - U_c^{\text{cons},\,y_1} = U_{nc}^{\text{cons},\,y_2} - U_{nc}^{\text{cons},\,y_1} = (1+\gamma)(x + price_{y_1}^{\text{cons}} - price_{y_2}^{\text{cons}}) \quad \text{if } a > 3x$$

and

$$U_c^{\text{cons},\,y_2} - U_c^{\text{cons},\,y_1} = U_{nc}^{\text{cons},\,y_2} - U_{nc}^{\text{cons},\,y_1} = \frac{3x + \rho\gamma b}{3} + (1+\gamma)(price_{y_1}^{\text{cons}} - price_{y_2}^{\text{cons}})$$

otherwise. When $a \geq 3x$, because y_1 would lose all consumers if $price_{y_1}^{\text{cons}} > price_{y_2}^{\text{cons}} - x$ but gain all consumers if $price_{y_1}^{\text{cons}} < price_{y_2}^{\text{cons}} - x$ in equilibrium $price_{y_1}^{\text{cons}}$ would be equal to zero and the follower's price $price_{y_2}^{\text{cons}}$ would be equal to x. Thus, $\pi_{y_1}^{\text{cons}} = 0$, $\pi_{y_2}^{\text{cons}} = x - D_3$ if $a \geq 3x$. Similarly, When $a < 3x$, we have $price_{y_1}^{\text{cons}} = 0$, $price_{y_2}^{\text{cons}} = \frac{3x+\rho\gamma b}{3(1+\gamma)}$, $\pi_{y_1}^{\text{cons}} = 0$, and $\pi_{y_2}^{\text{cons}} = \frac{3x+\rho\gamma b}{3(1+\gamma)} - D_3$.

The second cycle profits if the pioneer locates at (x, b) *and the follower adopts revolutionary strategy.* In this case, the reference point for the old product attribute is $\frac{a+2x}{3}$ and the reference point for the new product attribute is $\frac{2b+x}{3}$. The utility functions would be as follows:

$$U_c^{\text{rev},\,y_0} = a - \rho\gamma\frac{2b+x}{3},$$

$$U_c^{\text{rev},\,y_1} = \rho b + x - \gamma\frac{a-x}{3} - (1+\gamma)price_{y_1}^{\text{rev}},$$

$$U_c^{\text{rev},\,y_2} = \rho(b+x) + x - \gamma\frac{a-x}{3} - (1+\gamma)price_{y_2}^{\text{rev}},$$

$$U_{nc}^{\text{rev},\,y_0} = a - \gamma\frac{2b+x}{3},$$

$$U_{nc}^{\text{rev},\,y_1} = b + x - \gamma\frac{a-x}{3} - (1+\gamma)price_{y_1}^{\text{rev}},$$

$$U_{nc}^{\text{rev},\,y_2} = b + 2x - \gamma\frac{a-x}{3} - (1+\gamma)price_{y_2}^{\text{rev}}.$$

Thus, $U_c^{\text{rev},\,y_2} \geq U_c^{\text{rev},\,y_1}$ if $price_{y_2}^{\text{rev}} \leq \frac{\rho x}{1+\gamma} + price_{y_1}^{\text{rev}}$, $U_{nc}^{\text{rev},\,y_2} \geq U_{nc}^{\text{rev},\,y_1}$ if $price_{y_2}^{\text{rev}} \leq \frac{x}{1+\gamma} + price_{y_1}^{\text{rev}}$. If $price_{y_1}^{\text{rev}} + \frac{\rho x}{1+\gamma} > (price_{y_1}^{\text{rev}} + \frac{x}{1+\gamma})(1-\alpha)$, i.e., $price_{y_1}^{\text{rev}} > \frac{x(1-\alpha-\rho)}{\alpha(1+\gamma)}$, then the follower prefers to sell y_2 to all the consumers and in this $price_{y_2}^{\text{rev}} = 0$ and $price_{y_2}^{\text{rev}} = \frac{\rho x}{1+\gamma}$ in equilibrium, with $\pi_{y_1}^{\text{rev}} = 0$ and $\pi_{y_2}^{\text{rev}} = \frac{\rho x}{1+\gamma} - D_3$. The condition for this case to occur is $\frac{x(1-\alpha-\rho)}{\alpha(1+\gamma)} \leq 0$, which implies $\alpha \geq 1-\rho$. If $\alpha < 1-\rho$, then the follower sells y_2 only to the nonconservative segment, $price_{y_1}^{\text{rev}} = \max(\frac{x(1-\alpha-\rho)}{\alpha(1+\gamma)}, \frac{\rho\gamma b + x(3+\gamma(1+\rho))}{3(1+\gamma)})$, where $\frac{\rho\gamma b + x(3+\gamma(1+\rho))}{3(1+\gamma)}$ solves $U_c^{\text{rev},\,y_1} = U_c^{\text{rev},\,y_0}$. $\frac{x(1-\alpha-\rho)}{\alpha(1+\gamma)} \geq \frac{\rho\gamma b + x(3+\gamma(1+\rho))}{3(1+\gamma)}$ implies $\frac{3x(1-\rho)}{\rho\gamma b + x(6+\gamma(1+\rho))} \leq \alpha$. Thus, if $\frac{3x(1-\rho)}{\rho\gamma b + x(6+\gamma(1+\rho))} < \alpha < 1-\rho$, then $price_{y_1}^{\text{rev}} = \frac{x(1-\alpha-\rho)}{\alpha(1+\gamma)}$, $price_{y_2}^{\text{rev}} = (price_{y_1}^{\text{rev}} + \frac{x}{1+\gamma}) = \frac{x(1-\rho)}{\alpha(1+\gamma)}$, $\pi_{y_1}^{\text{rev}} = \frac{x(1-\alpha-\rho)}{1+\gamma}$, and $\pi_{y_2}^{\text{rev}} = \frac{x(1-\rho)}{\alpha(1+\gamma)}(1-\alpha) - D_3$. If $\alpha < \frac{3x(1-\rho)}{\rho\gamma b + x(6+\gamma(1+\rho))}$, then $price_{y_1}^{\text{rev}} = \frac{\rho\gamma b + x(3+\gamma(1+\rho))}{3(1+\gamma)}$, $price_{y_2}^{\text{rev}} = (price_{y_1}^{\text{rev}} + \frac{x}{1+\gamma}) = \frac{\rho\gamma b + x(6+\gamma(1+\rho))}{3(1+\gamma)}$, $\pi_{y_1}^{\text{rev}} = \frac{\rho\gamma b + x(3+\gamma(1+\rho))}{3(1+\gamma)}\alpha$, and $\pi_{y_2}^{\text{rev}} = \frac{\rho\gamma b + x(6+\gamma(1+\rho))}{3(1+\gamma)}(1-\alpha) - D_3$.

The pioneer's decision of locating at (x, b) *versus* $(0, b)$. Let $\pi_{\text{pioneer},1}^{(0,b)}$ and $\pi_{\text{pioneer},2}^{(0,b)}$ denote the pioneer's profits in the first product cycle and in the second product cycle, respectively, when it locates at $(0, b)$. Let $\pi_{\text{pioneer},1}^{(x,b)}$ and $\pi_{\text{pioneer},2}^{(x,b)}$ denote the pioneer's profits in the first product cycle and in the second product cycle respectively when it locates at (x, b). Then, $D_2^* = D_1 +$ *direct benefit of locating at* (x, b) + *strategic benefit of locating at* (x, b), where *direct benefit of locating at* $(x, b) = \pi_{\text{pioneer},1}^{(x,b)} - \pi_{\text{pioneer},1}^{(0,b)}$ and *strategic benefit of locating at* $(x, b) = \pi_{\text{pioneer},2}^{(x,b)} - \pi_{\text{pioneer},2}^{(0,b)}$.

(1) *Case of* $x \leq \frac{a}{3}$. By comparing the follower's profits under the conservative strategy and under the revolutionary strategy, one can see that if $\alpha \geq \frac{1-\rho}{2+\gamma-\rho}$, then $\pi_{y_2}^{\text{cons}} > \pi_{y_2}^{\text{rev}}$ and in such case $\pi_{y_1}^{\text{cons}} = 0$ in the second product cycle.

Therefore, if (Scenario 1)

$$\frac{1-\rho}{2+\gamma-\rho} \leq \alpha < \min\left\{\frac{3x(1-\rho)}{\rho\gamma b + x(3+\rho\gamma)}, \frac{\rho\gamma b - x\gamma(3-\rho)}{\rho\gamma b + x(3+\rho\gamma)}\right\},$$

the pioneer's total profits are equal to $\frac{(b-a)(2+\gamma)}{2(1+\gamma)}(1-\alpha) + \frac{\rho\gamma(b+x)}{3(1+\gamma)}\alpha - D_1$ when it locates at $(0, b)$ and to $\frac{(b-a+x)(2+\gamma)}{2(1+\gamma)} \cdot (1-\alpha) - D_2$ when it locates at (x, b). Thus, the pioneer would prefer to locate at $(0,b)$ if $D_2 > D_1 + \frac{x(2+\gamma)}{2(1+\gamma)}(1-\alpha) - \frac{\rho\gamma(b+x)}{3(1+\gamma)}\alpha = D_2^*$. Note that in this case the direct benefit of locating at (x,b) is equal to $\frac{x(2+\gamma)}{2(1+\gamma)}(1-\alpha)$ and the strategic benefit of locating at (x,b) is equal to $-\frac{\rho\gamma(b+x)}{3(1+\gamma)}\alpha$. We know from Lemma 4 that in the absence of context-dependent preferences, the direct benefit of locating at (x,b) is equal to $x(1-\alpha)$ and the strategic benefit of locating at (x,b) is equal to $x(1-\alpha-\rho)$ for $\frac{1-\rho}{2} < \alpha < \frac{1-\rho}{2-\rho}$, and equal to $x\alpha$ for $\alpha < \frac{1-\rho}{2}$. It is obvious that $\frac{x(2+\gamma)}{2(1+\gamma)}(1-\alpha) < x(1-\alpha)$. Given that $x(1-\alpha-\rho) > 0$ and $x\alpha > 0$, both the direct benefit and the strategic benefit of locating at (x,b) are smaller when the preferences are context dependent. Thus, D_2^* must be less than $\bar{D}_2$ for this scenario.

If $\alpha < \frac{1-\rho}{2+\gamma-\rho}$, then $\pi_{y_2}^{\text{cons}} < \pi_{y_2}^{\text{rev}}$, and hence the follower prefers to pursue the revolutionary strategy when the pioneer locates at (x,b). In this case, $\pi_{y_1}^{\text{rev}} = \frac{x(1-\alpha-\rho)}{1+\gamma}$ for $\frac{3x(1-\rho)}{\rho\gamma b+x(3+\rho\gamma)} < \alpha < \frac{1-\rho}{2+\gamma-\rho}$ and for

$$\frac{3x(1-\rho)}{\rho\gamma b+x(6+\gamma(1+\rho))} < \alpha < \min\left\{\frac{3x(1-\rho)}{\rho\gamma b+x(3+\rho\gamma)}, \frac{\rho\gamma b-x\gamma(3-\rho)}{\rho\gamma b+x(3+\rho\gamma)}, \frac{1-\rho}{2+\gamma-\rho}\right\},$$

and $\pi_{y_1}^{\text{rev}} = \frac{\rho\gamma b+x(3+\gamma(1+\rho))}{3(1+\gamma)}\alpha$ for

$$\alpha < \min\left\{\frac{3x(1-\rho)}{\rho\gamma b+x(6+\gamma(1+\rho))}, \frac{\rho\gamma b-x\gamma(3-\rho)}{\rho\gamma b+x(3+\rho\gamma)}, \frac{1-\rho}{2+\gamma-\rho}\right\}.$$

Therefore, if (Scenario 2) $\frac{3x(1-\rho)}{\rho\gamma b+x(3+\rho\gamma)} < \alpha < \frac{1-\rho}{2+\gamma-\rho}$, the pioneer's total profits are equal to $\frac{(b-a)(2+\gamma)}{2(1+\gamma)}(1-\alpha) + \frac{x(1-\alpha-\rho)}{1+\gamma} - D_1$ when it locates at $(0,b)$ and to $\frac{(b-a+x)(2+\gamma)}{2(1+\gamma)}(1-\alpha) + \frac{x(1-\alpha-\rho)}{1+\gamma} - D_2$ when it locates at (x,b). Thus, the pioneer would prefer to locate at $(0,b)$ if $D_2 > D_1 + \frac{x(2+\gamma)}{2(1+\gamma)}(1-\alpha) = D_2^*$. In this case the direct benefit of locating at (x,b) is equal to $\frac{x(2+\gamma)}{2(1+\gamma)}(1-\alpha)$ and the strategic benefit of locating at (x,b) is equal to zero. We know from Lemma 4 that in the absence of context-dependent preferences the direct benefit of locating at (x,b) is equal to $x(1-\alpha)$ and the strategic benefit of locating at (x,b) is equal to $x(1-\alpha-\rho)$ for $\frac{1-\rho}{2} < \alpha < \frac{1-\rho}{2-\rho}$, and $x\alpha$ for $\alpha < \frac{1-\rho}{2}$. It is obvious that $\frac{x(2+\gamma)}{2(1+\gamma)}(1-\alpha) < x(1-\alpha)$. Given that $x(1-\alpha-\rho) > 0$ and $x\alpha > 0$, both the direct benefit and the strategic benefit of locating at (x,b) are smaller when the preferences are context dependent. Thus, D_2^* must be less than $\bar{D}_2$ for this scenario.

If (Scenario 3)

$$\frac{3x(1-\rho)}{\rho\gamma b+x(6+\gamma(1+\rho))} < \alpha < \min\left\{\frac{3x(1-\rho)}{\rho\gamma b+x(3+\rho\gamma)}, \frac{\rho\gamma b-x\gamma(3-\rho)}{\rho\gamma b+x(3+\rho\gamma)}, \frac{1-\rho}{2+\gamma-\rho}\right\},$$

the pioneer's total profits are equal to $\frac{(b-a)(2+\gamma)}{2(1+\gamma)}(1-\alpha) + \frac{\rho\gamma(b+x)}{3(1+\gamma)}\alpha - D_1$ when it locates at $(0,b)$ and to $\frac{(b-a+x)(2+\gamma)}{2(1+\gamma)} \cdot (1-\alpha) + \frac{x(1-\alpha-\rho)}{1+\gamma} - D_2$ when it locates at (x,b). Thus, the pioneer would prefer to locate at $(0,b)$ if $D_2 > D_1 + \frac{x(2+\gamma)}{2(1+\gamma)} \cdot (1-\alpha) + \frac{x(1-\alpha-\rho)}{1+\gamma} - \frac{\rho\gamma(b+x)}{3(1+\gamma)}\alpha = D_2^*$. In this case the direct benefit of locating at (x,b) is equal to $\frac{x(2+\gamma)}{2(1+\gamma)}(1-\alpha)$ and the strategic benefit of locating at (x,b) is equal to $\frac{x(1-\alpha-\rho)}{1+\gamma} - \frac{\rho\gamma(b+x)}{3(1+\gamma)}\alpha$. We know from Lemma 4 that in the absence of context-dependent preferences the direct benefit of locating at (x,b) is equal to $x(1-\alpha)$ and the strategic benefit of locating at (x,b) is equal to $x(1-\alpha-\rho)$ for $\frac{1-\rho}{2} < \alpha < \frac{1-\rho}{2-\rho}$ and $x\alpha$ for $\alpha < \frac{1-\rho}{2}$. Note that $x\alpha > \frac{x(1-\alpha-\rho)}{1+\gamma} - \frac{\rho\gamma(b+x)}{3(1+\gamma)}\alpha$ if $\frac{3x(1-\rho)}{\rho\gamma b+x(6+\gamma(1+\rho))} < \alpha < \min\{\frac{3x(1-\rho)}{\rho\gamma b+x(3+\rho\gamma)}, \frac{\rho\gamma b-x\gamma(3-\rho)}{\rho\gamma b+x(3+\rho\gamma)}, \frac{1-\rho}{2}, \frac{1-\rho}{2+\gamma-\rho}\}$ and $x(1-\alpha-\rho) > \frac{x(1-\alpha-\rho)}{1+\gamma} - \frac{\rho\gamma(b+x)}{3(1+\gamma)}\alpha$ if $\frac{1-\rho}{2} < \alpha < \min\{\frac{3x(1-\rho)}{\rho\gamma b+x(3+\rho\gamma)}, \frac{\rho\gamma b-x\gamma(3-\rho)}{\rho\gamma b+x(3+\rho\gamma)}, \frac{1-\rho}{2+\gamma-\rho}\}$. Since $\frac{x(2+\gamma)}{2(1+\gamma)}(1-\alpha) < x(1-\alpha)$, both the direct benefit and the strategic benefit of locating at (x,b) are smaller when the preferences are context dependent. Thus, D_2^* must be less than $\bar{D}_2$ for this scenario.

If (Scenario 4)

$$\alpha < \min\left\{\frac{3x(1-\rho)}{\rho\gamma b+x(6+\gamma(1+\rho))}, \frac{\rho\gamma b-x\gamma(3-\rho)}{\rho\gamma b+x(3+\rho\gamma)}, \frac{1-\rho}{2+\gamma-\rho}\right\},$$

The pioneer's total profits are equal to $\frac{(b-a)(2+\gamma)}{2(1+\gamma)}(1-\alpha) + \frac{\rho\gamma(b+x)}{3(1+\gamma)}\alpha - D_1$ when it locates at $(0,b)$ and to $\frac{(b-a+x)(2+\gamma)}{2(1+\gamma)} \cdot (1-\alpha) + \frac{\rho\gamma b+x(3+\gamma(1+\rho))}{3(1+\gamma)}\alpha - D_2$ when it locates at (x,b). Thus, the pioneer would prefer to locate at $(0,b)$ if $D_2 > D_1 + \frac{x(2+\gamma)}{2(1+\gamma)}(1-\alpha) + \frac{x(3+\gamma)}{3(1+\gamma)}\alpha = D_2^*$. In this case the direct benefit of locating at (x,b) is equal to $\frac{x(2+\gamma)}{2(1+\gamma)}(1-\alpha)$ and the strategic benefit of locating at (x,b) is equal to $\frac{x(3+\gamma)}{3(1+\gamma)}\alpha$. We know from Lemma 4 that in the absence of context-dependent preferences, the direct benefit of locating at (x,b) is equal to $x(1-\alpha)$ and the strategic benefit of locating at (x,b) is equal to $x(1-\alpha-\rho)$ for $\frac{1-\rho}{2} < \alpha < \frac{1-\rho}{2-\rho}$ and $x\alpha$ for $\alpha < \frac{1-\rho}{2}$. It is obvious that $\frac{x(2+\gamma)}{2(1+\gamma)}(1-\alpha) < x(1-\alpha)$. Furthermore, $\frac{1-\rho}{2} > \frac{3x(1-\rho)}{\rho\gamma b+x(6+\gamma(1+\rho))}$. Since $x\alpha > \frac{x(3+\gamma)}{3(1+\gamma)}$ for $\alpha < \min\{\frac{3x(1-\rho)}{\rho\gamma b+x(6+\gamma(1+\rho))}, \frac{\rho\gamma b-x\gamma(3-\rho)}{\rho\gamma b+x(3+\rho\gamma)}, \frac{1-\rho}{2+\gamma-\rho}\}$ both the direct benefit and the strategic benefit of locating at (x,b) are smaller when the preferences are context dependent. Thus, D_2^* must be less than $\bar{D}_2$ for this scenario.

Finally, recall from Proposition 1 that region in which $\alpha < \bar{\alpha}$ consists of $0 < \alpha < \min\{\frac{3x(1-\rho)}{\rho\gamma b+x(3+\rho\gamma)}, \frac{\rho\gamma b-x\gamma(3-\rho)}{\rho\gamma b+x(3+\rho\gamma)}\}$ and $\frac{3x(1-\rho)}{\rho\gamma b+x(3+\rho\gamma)} < \alpha < \frac{1-\rho}{2+\gamma-\rho}$. Hence, the total of regions covered in Scenarios 1–4, i.e.,

$$\alpha < \min\left\{\frac{3x(1-\rho)}{\rho\gamma b+x(6+\gamma(1+\rho))}, \frac{\rho\gamma b-x\gamma(3-\rho)}{\rho\gamma b+x(3+\rho\gamma)}, \frac{1-\rho}{2+\gamma-\rho}\right\}, \frac{3x(1-\rho)}{\rho\gamma b+x(6+\gamma(1+\rho))}$$
$$< \alpha < \min\left\{\frac{3x(1-\rho)}{\rho\gamma b+x(3+\rho\gamma)}, \frac{\rho\gamma b-x\gamma(3-\rho)}{\rho\gamma b+x(3+\rho\gamma)}, \frac{1-\rho}{2+\gamma-\rho}\right\},$$
$$\frac{3x(1-\rho)}{\rho\gamma b+x(3+\rho\gamma)} < \alpha < \frac{1-\rho}{2+\gamma-\rho},$$
$$\frac{1-\rho}{2+\gamma-\rho} \le \alpha < \min\left\{\frac{3x(1-\rho)}{\rho\gamma b+x(3+\rho\gamma)}, \frac{\rho\gamma b-x\gamma(3-\rho)}{\rho\gamma b+x(3+\rho\gamma)}\right\},$$

is equal to $\alpha < \bar{\alpha}$.

(2) *Case of* $\frac{a}{3} < x < \frac{a}{2}$. By comparing the follower's profits under the conservative strategy and under the revolutionary strategy, one can see that if $\alpha > \frac{3x(1-\rho)}{\rho\gamma b+3x(2-\rho)}$, then $\pi_{y_2}^{\text{cons}} > \pi_{y_2}^{\text{rev}}$, and hence the follower prefers to pursue the conservative strategy. In this case $\pi_{y_1}^{\text{cons}} = 0$ in the second product cycle.

Note that $\frac{3x(1-\rho)}{\rho\gamma b+3x(2-\rho)} > \frac{1-\rho}{2+\gamma-\rho}$. Therefore, for $\frac{a}{3} < x < \frac{a}{2}$ the follower prefers to pursue the revolutionary strategy if $\frac{3x(1-\rho)}{\rho\gamma b+x(3+\rho\gamma)} < \alpha < \frac{1-\rho}{2+\gamma-\rho}$ or if $\alpha < \min\{\frac{3x(1-\rho)}{\rho\gamma b+x(3+\rho\gamma)}, \frac{\rho\gamma b-x\gamma(3-\rho)}{\rho\gamma b+x(3+\rho\gamma)}, \frac{3x(1-\rho)}{\rho\gamma b+3x(2-\rho)}\}$ and conservative strategy if $\frac{3x(1-\rho)}{\rho\gamma b+3x(2-\rho)} < \alpha < \min\{\frac{3x(1-\rho)}{\rho\gamma b+x(3+\rho\gamma)}, \frac{\rho\gamma b-x\gamma(3-\rho)}{\rho\gamma b+x(3+\rho\gamma)}\}$. In this case, in the second product cycle the pioneer's profits are $\pi_{y_1}^{\mathrm{rev}} = \frac{x(1-\alpha-\rho)}{1+\gamma}$ if $\frac{3x(1-\rho)}{\rho\gamma b+x(3+\rho\gamma)} < \alpha < \frac{1-\rho}{2+\gamma-\rho}$ and if $\frac{3x(1-\rho)}{\rho\gamma b+x(6+\gamma(1+\rho))} < \alpha < \min\{\frac{3x(1-\rho)}{\rho\gamma b+x(3+\rho\gamma)}, \frac{\rho\gamma b-x\gamma(3-\rho)}{\rho\gamma b+x(3+\rho\gamma)}, \frac{3x(1-\rho)}{\rho\gamma b+3x(2-\rho)}\}$, the pioneer's profits are $\pi_{y_1}^{\mathrm{rev}} = \frac{\rho\gamma b+x(3+\gamma(1+\rho))}{3(1+\gamma)}\alpha$ if $\alpha < \min\{\frac{3x(1-\rho)}{\rho\gamma b+x(6+\gamma(1+\rho))}, \frac{\rho\gamma b-x\gamma(3-\rho)}{\rho\gamma b+x(3+\rho\gamma)}\}$, and the pioneer's profits are $\pi_{y_1}^{\mathrm{cons}} = 0$ if $\frac{3x(1-\rho)}{\rho\gamma b+3x(2-\rho)} < \alpha < \min\{\frac{3x(1-\rho)}{\rho\gamma b+x(3+\rho\gamma)}, \frac{\rho\gamma b-x\gamma(3-\rho)}{\rho\gamma b+x(3+\rho\gamma)}\}$.

Therefore, (Scenario 5) for $\frac{3x(1-\rho)}{\rho\gamma b+x(3+\rho\gamma)} < \alpha < \frac{1-\rho}{2+\gamma-\rho}$, the pioneer would prefer to locate at $(0, b)$ if $D_2 > D_1 + \frac{x(2+\gamma)}{2(1+\gamma)} \cdot (1-\alpha) = D_2^*$. In this case the direct benefit of locating at (x, b) is equal to $\frac{x(2+\gamma)}{2(1+\gamma)}(1-\alpha)$ and the strategic benefit of locating at (x, b) is equal to zero. We know from Lemma 4 that in the absence of context-dependent preferences, the direct benefit of locating at (x, b) is equal to $x(1-\alpha)$ and the strategic benefit of locating at (x, b) is equal to $x(1-\alpha-\rho)$ for $\frac{1-\rho}{2} < \alpha < \frac{1-\rho}{2-\rho}$, and $x\alpha$ for $\alpha < \frac{1-\rho}{2}$. It is obvious that $\frac{x(2+\gamma)}{2(1+\gamma)}(1-\alpha) < x(1-\alpha)$. Given that $x(1-\alpha-\rho) > 0$ and $x\alpha > 0$, both the direct benefit and the strategic benefit of locating at (x, b) are smaller when the preferences are context dependent. Thus, D_2^* must be less than $\bar{D}_2$ for this scenario.

(Scenario 6) For

$$\frac{3x(1-\rho)}{\rho\gamma b+x(6+\gamma(1+\rho))} < \alpha < \min\left\{\frac{3x(1-\rho)}{\rho\gamma b+x(3+\rho\gamma)}, \frac{\rho\gamma b-x\gamma(3-\rho)}{\rho\gamma b+x(3+\rho\gamma)}, \frac{3x(1-\rho)}{\rho\gamma b+3x(2-\rho)}\right\}$$

the pioneer would prefer to locate at $(0, b)$ if $D_2 > D_1 + \frac{x(2+\gamma)}{2(1+\gamma)}(1-\alpha) + \frac{x(1-\alpha-\rho)}{(1+\gamma)} - \frac{\rho\gamma(b+x)}{3(1+\gamma)}\alpha = D_2^*$. In this case the direct benefit of locating at (x, b) is equal to $\frac{x(2+\gamma)}{2(1+\gamma)}(1-\alpha)$ and the strategic benefit of locating at (x, b) is equal to $\frac{x(1-\alpha-\rho)}{1+\gamma} - \frac{\rho\gamma(b+x)}{3(1+\gamma)}\alpha$. We know from Lemma 4 that in the absence of context-dependent preferences, the direct benefit of locating at (x, b) is equal to $x(1-\alpha)$ and the strategic benefit of locating at (x, b) is equal to $x(1-\alpha-\rho)$ for $\frac{1-\rho}{2} < \alpha < \frac{1-\rho}{2-\rho}$ and $x\alpha$ for $\alpha < \frac{1-\rho}{2}$. It is obvious that $\frac{x(2+\gamma)}{2(1+\gamma)}(1-\alpha) < x(1-\alpha)$. Note that

$$x\alpha > \frac{x(1-\alpha-\rho)}{1+\gamma} - \frac{\rho\gamma(b+x)}{3(1+\gamma)}\alpha \quad \text{if } \frac{3x(1-\rho)}{\rho\gamma b+x(6+\gamma(1+\rho))} < \alpha < \min\left\{\frac{3x(1-\rho)}{\rho\gamma b+x(3+\rho\gamma)}, \frac{\rho\gamma b-x\gamma(3-\rho)}{\rho\gamma b+x(3+\rho\gamma)}, \frac{3x(1-\rho)}{\rho\gamma b+3x(2-\rho)}, \frac{1-\rho}{2}\right\}$$

and

$$x(1-\alpha-\rho) > \frac{x(1-\alpha-\rho)}{1+\gamma} - \frac{\rho\gamma(b+x)}{3(1+\gamma)}\alpha \quad \text{if } \frac{1-\rho}{2} < \alpha < \min\left\{\frac{3x(1-\rho)}{\rho\gamma b+x(3+\rho\gamma)}, \frac{\rho\gamma b-x\gamma(3-\rho)}{\rho\gamma b+x(3+\rho\gamma)}, \frac{3x(1-\rho)}{\rho\gamma b+3x(2-\rho)}\right\}.$$

Thus, both the direct benefit and the strategic benefit of locating at (x, b) are smaller when the preferences are context dependent. Thus, D_2^* must be less than $\bar{D}_2$ for this scenario.

(Scenario 7) For $\alpha < \min\{\frac{3x(1-\rho)}{\rho\gamma b+x(6+\gamma(1+\rho))}, \frac{\rho\gamma b-x\gamma(3-\rho)}{\rho\gamma b+x(3+\rho\gamma)}\}$ the pioneer would prefer to locate at $(0, b)$ if $D_2 > D_1 + \frac{x(2+\gamma)}{2(1+\gamma)} \cdot (1-\alpha) + \frac{x(3+\gamma)}{3(1+\gamma)}\alpha = D_2^*$. And in this case the strategic benefit of locating at (x, b) is equal to $\frac{x(3+\gamma)}{3(1+\gamma)}\alpha$. We know from Lemma 4 that in the absence of context-dependent preferences, the direct benefit of locating at (x, b) is equal to $x(1-\alpha)$ and the strategic benefit of locating at (x, b) is equal to $x(1-\alpha-\rho)$ for $\frac{1-\rho}{2} < \alpha < \frac{1-\rho}{2-\rho}$ and $x\alpha$ for $\alpha < \frac{1-\rho}{2}$. It is obvious that $\frac{x(2+\gamma)}{2(1+\gamma)}(1-\alpha) < x(1-\alpha)$. Note that $x\alpha > \frac{x(3+\gamma)}{3(1+\gamma)}\alpha$ if $\alpha < \min\{\frac{3x(1-\rho)}{\rho\gamma b+x(6+\gamma(1+\rho))}, \frac{\rho\gamma b-x\gamma(3-\rho)}{\rho\gamma b+x(3+\rho\gamma)}\}$ and $\frac{3x(1-\rho)}{\rho\gamma b+x(6+\gamma(1+\rho))} < \frac{1-\rho}{2}$. Thus, both the direct benefit and the strategic benefit of locating at (x, b) are smaller when the preferences are context dependent. Thus, D_2^* must be less than $\bar{D}_2$ for this scenario.

(Scenario 8) For

$$\frac{3x(1-\rho)}{\rho\gamma b+3x(2-\rho)} < \alpha < \min\left\{\frac{3x(1-\rho)}{\rho\gamma b+x(3+\rho\gamma)}, \frac{\rho\gamma b-x\gamma(3-\rho)}{\rho\gamma b+x(3+\rho\gamma)}\right\}$$

the pioneer would prefer to locate at $(0, b)$ if $D_2 > D_1 + \frac{x(2+\gamma)}{2(1+\gamma)}(1-\alpha) - \frac{\rho\gamma(b+x)}{3(1+\gamma)}\alpha = D_2^*$. And in this case the strategic benefit of locating at (x, b) is equal to $-\frac{\rho\gamma(b+x)}{3(1+\gamma)}\alpha$. We know from Lemma 4 that in the absence of context-dependent preferences, the direct benefit of locating at (x, b) is equal to $x(1-\alpha)$ and the strategic benefit of locating at (x, b) is equal to $x(1-\alpha-\rho)$ for $\frac{1-\rho}{2} < \alpha < \frac{1-\rho}{2-\rho}$ and $x\alpha$ for $\alpha < \frac{1-\rho}{2}$. It is obvious that $\frac{x(2+\gamma)}{2(1+\gamma)}(1-\alpha) < x(1-\alpha)$. Given that $x(1-\alpha-\rho) > 0$ and $x\alpha > 0$, both the direct benefit and the strategic benefit of locating at (x, b) are smaller when the preferences are context dependent. Thus, D_2^* must be less than $\bar{D}_2$ for this scenario.

Finally, the total of regions covered in Scenarios 5–8, i.e.,

$$\frac{3x(1-\rho)}{\rho\gamma b + x(3+\rho\gamma)} < \alpha < \frac{1-\rho}{2+\gamma-\rho},$$

$$\frac{3x(1-\rho)}{\rho\gamma b + 3x(2-\rho)} < \alpha < \min\left\{\frac{3x(1-\rho)}{\rho\gamma b + x(3+\rho\gamma)}, \frac{\rho\gamma b - x\gamma(3-\rho)}{\rho\gamma b + x(3+\rho\gamma)}\right\},$$

$$\alpha < \min\left\{\frac{3x(1-\rho)}{\rho\gamma b + x(6+\gamma(1+\rho))}, \frac{\rho\gamma b - x\gamma(3-\rho)}{\rho\gamma b + x(3+\rho\gamma)}\right\},$$

$$\frac{3x(1-\rho)}{\rho\gamma b + x(6+\gamma(1+\rho))} < \alpha < \min\left\{\frac{3x(1-\rho)}{\rho\gamma b + x(3+\rho\gamma)}, \frac{\rho\gamma b - x\gamma(3-\rho)}{\rho\gamma b + x(3+\rho\gamma)}, \frac{3x(1-\rho)}{\rho\gamma b + 3x(2-\rho)}\right\},$$

is equal to $\alpha < \bar{\alpha}$. □

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