IMPACTS OF CORPORATE SOCIAL RESPONSIBILITY ON NEW PRODUCT DEVELOPMENT

A Dissertation

Presented to

The Faculty of the C.T. Bauer College of Business

University of Houston

In Partial Fulfilment

Of the Requirements for the Degree

Doctor of Philosophy

By

Hannan Sadjady Naeeni

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IMPACTS OF CORPORATE SOCIAL RESPONSIBILITY
ON NEW PRODUCT DEVELOPMENT

Approved:

_____

E. Powell Robinson, Professor of Supply Chain Management
Chairperson of Committee

_____

Funda Sahin, Associate Professor of Supply Chain Management
Chairperson of Committee

_____

Nickolas Freeman, Assistant Professor of Operations Management

_____

James Hess, Professor of Marketing

_____

Paul A. Pavlou, Dean
C.T. Bauer College of Business

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Abstract

Incorporating corporate social responsibility (CSR) considerations into product positioning decisions is an important element of the sustainable agenda for many firms. Offering a socially responsible (SR) product is expected to increase revenues due to an improved brand image, penetration into new SR market segments and the consumers' willingness to pay a premium for an SR product. However, it can also have an adverse impact on production and supply chain costs, and elicit market response from rivals. We propose a game-theoretic duopoly model to identify product differentiation strategies, where one, none, or both firms offer socially responsible (SR) products at market equilibrium.

The findings of this research contribute to the CSR product positioning literature and provides multi-disciplinary insights for strategically positioning socially responsible products in competitive markets. We show how the decision to offer an SR product depends upon the marginal cost increase of the SR product, potential market growth and the impact of the SR product on the firm's brand image, as well as the interactions among these factors. The research examines the strategic implications of offering SR products and is the first to identify the conditions, where offering SR products can lead to intensified price competition and significant profit loss. We show that competing firms can become trapped in a prisoner's dilemma, where both firms choose to offer competing SR products, even though it leads to a decline in profits for both. We further show how a high marginal cost for providing an SR product can lead to a quasi-monopoly situation, where one firm offers the SR product and the other a non-SR product, but both firms earn higher profits than the status quo.

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1. Introduction

Increased consumer awareness of corporate social responsibility (CSR) elevates its status as an important product differentiator in the marketplace. The decision to offer a socially responsible (SR) product has a direct impact on a firm's profits and competitive position in the market place. It can lead to improved brand image and market growth, but it can also have an adverse impact on production and supply chain costs, and trigger market response from rivals. Thus, strategic product positioning requires a multi-disciplinary business perspective and has considerable implications for a firm's functional strategies, including marketing, operations and supply chain management (Kotler & Keller, 2008; Lauga & Ofek, 2011).

The Honest Company, a manufacturer and distributor of health-care products, illustrates SR-based strategic product positioning. The firm, born out of a simple purpose: "to create safe, effective products for our families and yours" rests its success on the diligent design of products that avoid chemicals of concern when it comes to ingredient, manufacturing and packaging selections—even if it means higher supply chain costs and product prices (The Honest Company, 2019). Their SR product positioning strategy enhances consumer trust and market acceptance from SR-oriented consumers and casts a positive effect on the firm's brand image.

SR product positioning also plays a major role in service systems. McDonald's recently announced a 10-year plan to fully transition to SR cage-free eggs for its nearly 16,000 restaurants in the U.S. and Canada (Worland, September 9, 2015). The shift to cage-free eggs, where hens are provided open areas for recreation and socialization, responds to allegations that traditional henhouses do not provide a healthy or SR

environment for the flocks. McDonald's currently purchases 2 billion eggs per year, but only 13 million (0.65%) are cage-free. Transitioning to a cage-free egg supply chain will require several years to develop the supply base and is estimated to cost the company $7 billion, which is equivalent to the USA's annual egg retail sales (Kowitt, 18 August 2016b). However, Steve Easterbrook, McDonald's CEO, argues that moving to cage-free eggs will improve the firm's SR brand image, and consequently sales growth. McDonald's commitment to cage-free eggs created a ripple effect in the industry with more than 200 restaurants following McDonald's lead to serve 100% cage-free eggs (Kowitt, 18 August 2016a).

In many cases, the set of product attributes on which the firms' compete for consumer acceptance are known, and the positioning decision determines the level of each product attribute to offer to the marketplace. When there is a dominant product attribute driving consumer choice, market competition and product differentiation should be along this primary dimension plus the firm's brand image, which reflects a composite perspective of the firm's products and services. For example, in purchasing an SR hybrid electric vehicle, consumers might primarily care about the vehicle's energy efficiency, but also be influenced by overall perceptions of the firm's brand image in terms of product safety, quality, service availability, financing and other factors. Returning to the Honest Company and McDonald's, the decision to offer SR products will potentially enhance the firm's brand image and sales in their current market segments and attract new sales from the SR "hardcore" market segment, whose members will only purchase SR products.

In setting SR attribute levels, the firm must carefully balance the benefit of offering the SR product to the customer against the marginal supply chain costs for providing the SR versus the standard non-SR product (N product). In a competitive market, the firm should also consider the position of the rival firms' products and how differentiated the products should be from one another.

Whether or not specific investments in SR products are economically sound remain to be seen. However, they raise several important managerial questions:

- Under what conditions should firms offer the standard product or a more expensive SR variant to the marketplace?
- What are potential risks and gains associated with offering SR products?

This research contributes by shedding light on the answers to the above questions. This is accomplished by developing a game-theoretic duopoly model that establishes the economic equilibria conditions where one, both or neither competitor offers an SR product. We identify the demand and supply conditions where offering an SR product will increase, diminish, or maintain the competitors' profits. We also investigate the impact of SR product positioning strategies on the consumers' total utility and economic welfare.

Our analysis uncovers several important findings. First, we show that whether one or both firms offer SR products depends on the impact of the SR product on consumers' brand perceptions, market growth and the marginal cost increase. We find that when the market growth associated with introducing SR products is high enough, one firm provides the SR product and the other the N product. However, for lower market growth

values, both firms offer the SR product when the SR product's marginal cost is relatively low, and offer the non-SR product when the marginal cost of the SR product is relatively high. Furthermore, the SR product's impact on consumer brand perception shifts the marginal cost and market growth thresholds associated with the firms' SR development strategies.

Second, we provide guidelines for determining when offering an SR product can reduce, improve, or have no effect on the firm's profitability. Marginal cost differences, market growth, and changes in consumer's brand perception play critical roles in this finding. When the SR product has a negative (horns[1]) effect on brand image, both firms encounter a win-win situation, where either one or both firms offer the SR product. However, when the SR product has a positive (halo) effect on brand image, offering the SR product can lead to intensified price competition and significant profit loss for one or both firms. We show that the firms can encounter a prisoner's dilemma that traps both firms into offering the SR product even though it results in a loss-loss profit situation.

The research contributes to the literature by simultaneously considering: the market growth derived from sales to the hardcore SR market segment that would not previously buy the standard non-SR product, the SR product's impact on the firm's brand image and market demand, the marginal cost increase for providing the SR product variant, and heterogeneous customer preferences with respect to their ideal brand and their willingness-to-pay a premium for the SR product. While the literature addresses

[1] The horns (halo) effect relates to negative (positive) connotations associated with an SR product. Organic insect repellant and organic cleansers provide examples, where on the one hand, customers prefer the SR aspect of the product which has a positive impact on brand image, but have a negative reaction fearing that the SR aspects of the product will compromise the effectiveness of the product's performance.

subsets of these factors independently, this study integrates them into a unique duopoly model, which shows how they jointly affect the SR product positioning decision, and why it is important to simultaneously consider these factors. The results provide important contributions to the CSR product positioning literature and managerial decision-making.

This dissertation is presented in six chapters. The purpose of the study and importance of the research area is introduced in this first chapter. Chapter 2 reviews the extant literature on product positioning and SR product development, and highlights our contributions to the literature. The research methodology including analytical model and solution procedure is provided in chapter 3. Chapter 4 summarizes the results of the base model. Extensions to the base model are discussed in Chapter 5. We conclude by discussing the results and managerial implications of the research in Chapter 6.

2. Literature Review

This study contributes to the body of research at the intersection of CSR and product positioning. SR product positioning is an example of what Baron (2001) calls strategic CSR: attempts to increase profits by attracting "green" or socially responsible consumers. We model strategic CSR arising from companies seeking competitive advantage in their product markets through SR product positioning. The literature survey is organized in two sections. First, we briefly discuss the CSR literature and the role of product positioning within this broader context. Next, we review the analytical models in the product positioning literature with a focus on duopoly models of market equilibrium.

2.1. Corporate Social Responsibility

Recognizing the importance of environmental and social considerations, more firms are incorporating corporate social responsibility (CSR) as key elements of their business models and strategies (Besiou & Van Wassenhove, 2015; Letizia & Hendrikse, 2016; Sila, 2018). However, despite the rapidly growing literature on the topic, there is no general consensus on the definition of CSR and the activities covered under the CSR umbrella (Servaes & Tamayo, 2013; Sila, 2018). Baron (2001) states that "Corporate social responsibility is an ill- and incompletely defined concept", and Sodhi (2015) argues that the operations management boundaries of CSR and other related concepts (e.g., environmentally responsible operations, sustainable supply chains, sustainable operations, sustainable purchasing) are unclear. We adopt the following CSR definition suggested by Letizia and Hendrikse (2016):

> *"Corporate social responsibility (CSR) refers to the [moral] obligations of the firm to a broad set of stakeholders that go beyond the firm shareholders. Business leaders and entrepreneurs embracing CSR activities are focused on optimizing the profits of the firm, while ensuring positive impacts (and/or reducing negative impacts) of the firm's business to the planet and the society at large (triple bottom line: profits, planet, and people)".*

This definition is consistent with Dahlsrud (2008), who identifies five key dimensions of CSR in the literature: The environmental, social, economic, stakeholder, and voluntariness dimensions. Sheffi (2018) finds that corporate sustainability efforts underpin companies' struggles to "bridge the gap between the conflicting constraints imposed and desires expressed by customers, competitors, employees, neighbors, investors, activists, local governments, and regulators". In addition, CSR covers a broad range of activities such as "corporate-level donations to nonprofits (e.g., the Metropolitan Opera) and causes (e.g., breast cancer research), and corporate commitment to the community and the environment (e.g., green products, pollution reduction, recycling, elimination of animal testing)" (Krishna & Rajan, 2009).

Within the broad scope of strategic CSR, this research addresses SR product positioning, which can be viewed as a preamble to sustainable product development (Carrillo, Druehl, & Hsuan, 2015). Incorporating CSR and sustainability into product positioning strategy can play a critical role in achieving operations excellence, creating competitive advantage in the marketplace and pursuing societal sustainability (Noori & Chen, 2003). As such, it is an important element of sustainable operations and supply chain management research(Linton, Klassen, & Jayaraman, 2007). However, Tang and

Zhou (2012) find quantitative modeling of CSR product positioning to be quite limited with the dominant sustainable-research paradigm focusing on closed-loop supply chains. Accordingly, studies typically revolve around product re-manufacturability, reverse logistics and product returns (Carrillo et al., 2015; Guide Jr & Van Wassenhove, 2009; Tang & Zhou, 2012). Please see (Ferguson & Souza, 2010) and (Souza, 2013) for comprehensive reviews of the closed loop supply chain literature.

In a seminal paper on green product development, Chen (2001) views a product's greenness feature as a quality attribute, which deviates from the product's traditional performance attributes. He proposes a quality-based model to analyze a monopolist's strategic decisions when choosing the products' quality combinations and its selling price. He finds conditions, where green product development and stricter environmental standards might not benefit the environment.

Bagnoli and Watts (2003) adopt a framework, where firms compete for SR consumers by linking their "private" product sales to contributions supporting SR public goods or activities. The basic idea is that consumers may have a greater willingness-to-pay for firms that engage in such SR activities. The research considers two cases: The firm donates a percentage of its sales to the SR cause or contributes lump-sum donations independent of the sales level. Both cases evaluate the trade-off between more efficient provision of the firm's traditional N product and the SR public good. They find that provision of the public SR good varies inversely with the competitiveness of the traditional private-good market.

Krishna and Rajan (2009) examine spillover effects in cause marketing, which is joining with charities or social causes to market a product or service. In a duopoly

competition model with each firm offering two products, the objective is to determine which products a firm should link to an SR cause. They find that linking one product in the product portfolio to an SR cause can increase that product's sales and, via a spillover effect, the sales of other products in the portfolio. In market equilibrium, each firm links only one of its products to the societal cause, but raises the prices on both products and earns higher profits.

In a duopoly model of vertical differentiation, García-Gallego and Georgantzís (2009) study market equilibrium and social welfare finding that an increase in consumers' social consciousness (e.g., willingness-to-pay for SR products) yields higher profits to SR firms and may lead to higher levels of social welfare. However, an increase in the consumers' social consciousness may change the market structure from complete to incomplete market coverage in a welfare-reducing fashion.

Iyer and Soberman (2016) investigate consumers' social comparison effects on the incentives of firms to invest in SR product innovations. A consumer enjoys a social comparison benefit (cost) when he interacts with another consumer who consumes less (more) SR product. The findings show that when the economic value of the product is low (high), the incentive to invest in SR innovation decreases (increases) as social comparison effects increase. Furthermore, social comparison benefits soften price competition, whereas social comparison costs intensify price competition.

Banerjee and Wathieu (2017) study the relationship between CSR and product quality, and find that CSR is a substitute for product quality. They show that in a monopoly, or a duopoly where the quality differentiation is sufficiently large, the high

quality product is offered with a lower level of CSR than the low quality product. In other words, firms that offer lower quality products invest more in CSR.

Firms anticipate increasing their market share by committing to SR products. This market growth can be due to more frequent sales to the firm's current customers, as well as attracting new customers. Previous studies identify two consumer self-selected market segments based on different valuations of social/environmental product attributes: The ordinary and the hardcore SR (green) market segments (see e.g. Atasu, Sarvary, & Van Wassenhove, 2008; Chen, 2001). While all customers prefer a product to be more socially/environmentally friendly, unlike ordinary customers, hardcore SR consumers will not buy the standard (non-SR) products. Thus, the hardcore SR market segment can only be tapped into by offering SR products. In selecting the product positioning strategy, firms should consider opportunities in both ordinary and hardcore market segments.

The literature also suggests that offering an SR product may have a spill-over effect on the firm's brand image and existing product portfolio leading to increased sales (Becker-Olsen, Cudmore, & Hill, 2006; Klein & Dawar, 2004; Lichtenstein, Drumwright, & Braig, 2004). This is often denoted as a halo or horns influence. A halo (horns) effect due to offering the SR product casts a positive (negative) shadow on the firm's brand image. Returning to the Honest Company, their strategy of avoiding "chemicals of concern" casts a halo on their brand image for customers most concerned about product safety. However, those seeking an industrial strength cleaner may view SR products as having lower cleansing ability and horns impact on the firm's brand image. Whether the firm experiences a halo or horns effect ultimately boils down to how strongly the

customer market segments feel about the effects of the SR attribute on the product characteristics.

As indicated by Honest Company, introducing SR products also has implications for the firm's supply chain strategy, including the selection of ingredients, suppliers, production and distribution processes, which often results in higher unit costs. Therefore, the trade-off between sales growth from offering a more appealing product and total supply chain cost should be considered.

Finally, the product position of rival products cannot be ignored. The relative positioning and pricing strategies of both firms ultimately determine their individual market share and profitability.

2.2. Strategic Product Positioning: Product Differentiation

2.2.1. Product Differentiation

A frequent assumption in the operations and supply chain management and industrial organization literature is that goods, produced by different firms, are homogeneous, that is perfect substitutes. The product positioning literature relaxes this assumption and allows for differentiated goods, which are substitutes but not perfect substitutes.

Two models of products differentiation prevail, namely horizontal and vertical differentiation. Product attributes are horizontally differentiated when there is no consistent ranking of products among consumers based on their willingness-to-pay (i.e., utility). This can be associated with brand image (e.g., Toyota versus Ford), product type (e.g., front-loading versus top-loading washing machines) or product taste (e.g., Pepsi

versus Coca Cola). The basic criteria is that given all other factors being equal, including price, some consumers place greater value on one product, while the others prefer another.

Vertical differentiation considers “quality” differences between products. Products are vertically differentiated when there is a consistent utility ranking among consumers. That is, all consumers have greater willingness-to-pay for higher levels of product quality, given all other factors being equal. For example, all consumers prefer computer laptops with faster processors assuming that all other factors remain the same.

Analytical models for product positioning vary by the type of product differentiation. As discussed in the literature survey that follows, some models assume product differentiation is on a single horizontal or vertical product attribute, some allow multiple attributes of the same type, while others simultaneously consider a horizontal and vertical differentiation. Model structures and product positioning equilibrium are highly dependent on product differentiation type. We briefly review the product differentiation literature most closely related to this research, which illustrates how different market characteristics lead to different product positioning strategies in equilibrium. See Table 1 for summary of relevant product positioning studies in the Literature.

Table 1 Summary of Relevant Product Positioning Literature

	Decision Variable(s)	Model Specifications						Conclusion
		Differentiation Dimension(s)	Customers' distribution	Endogenous Pricing	Increasing Marginal cost	Brand Image	Market Growth	
Hotelling (1929)	Position	Horizontal	Uniform					Minimum Differentiation
d'Aspremont et al. (1979)	Price, Position	Horizontal	Uniform	X				Maximum Differentiation
Shaked and Sutton (1982)	Price, Position	Vertical	Uniform	X				Partial Differentiation
Moorthy, (1988)	Price, Position	Vertical	Uniform	X	X			Partial Differentiation, conditional on marginal cost
Neven (1986)	Price, Position	Horizontal	Non-Uniform	X				Max (partial) Differentiation for non-concentrated (concentrated) distributions
Tabuchi and Thisse (1995)	Price, Position	Vertical	Triangular					Partial differentiation
Irmen & Thisse (1998)	Price, Position	n-Horizontal	Uniform	X				Max-Min Differentiation
Neven and Thisse (1990)	Price, Position	1-Horizontal 1-Vertical	Uniform	X				Max-Min Differentiation
Vandenbosch & Weinberg (1995)	Price, Position	2- Vertical	Uniform	X				Max-Min, Max-Max, and Partial-Max
Lauga and Ofek (2011)	Price, Position	2- Vertical	Uniform	X	X			Marginal cost dependent strategies
Ansari, Economides, and Ghosh (1994)	Price, Position	2- Vertical	Beta	X				Distribution dependent pricing and positioning equilibria
Current Study	Price, Position	1- Horizontal, 1- Vertical	Uniform	X	X	X	X	Conditions where one, none, or both of the firms make commitments to socially responsible products at equilibrium

2.2.2. Product Positioning and Differentiation Models

The product differentiation literature has evolved dramatically since the seminal work of (Hotelling, 1929). We describe Hotelling's research in moderate detail to identify the basic problem assumptions and research methodology in the product positioning literature.

Hotelling shows that the independent actions of two duopolistic competitors, not in collusion, lead to a type of market equilibrium where neither merchant can increase his profit by changing his price to gain market share. The equilibrium exhibits the "principle of minimum differentiation" – such that the competing firms should make their products as similar as possible. Hotelling's "linear city" model's assumptions include: (1) prices are exogenous; (2) product differentiation on *location*[2], a horizontal attribute; (3) consumer' preference; (4) market demand is fully covered, thus perfectly inelastic; and (5) production cost at each competitor is identical, i.e., marginal costs of product differentiation are zero.

2.2.2.1. Single-attribute Product Differentiation

In a duopoly with price competition, d'Aspremont, Gabszewicz, and Thisse (1979) show that Hotelling's minimum differentiation principle no longer holds. They argue that maximum product differentiation is the optimal strategy when firms first set the level of the horizontal characteristic of their product, and then compete on price. When firms differentiate on vertical product attributes (such as quality, or greenness), Shaked and

[2] There are many causes (e.g., proximity, mode of doing business, service offerings, product selection) leading particular buyers to prefer one seller to another, with the ensemble of such consideration symbolized by a linear transportation cost from a buyer's location to the seller's location.

Sutton (1982) demonstrate that firms should pursue partial product differentiation to relax price competition.

Moorthy (1988) considers two firms competing on quality (i.e., a vertical differentiation) and price, with a higher quality product costing more to produce than a lower quality product. Consumers differ in how much they are willing-to-pay for quality and may choose a substitute product if they don't like the quality-price offerings of the two firms. The results show that the firms should partially differentiate their products, with the firm offering the higher quality product also pricing at higher profit margins. The best quality level depends on the marginal increase in quality cost. Moorthy's analysis is the first research to capture the trade-off between the benefits and costs of product differentiation in determining market equilibrium. The majority of studies in the literature assume identical (zero) marginal costs for all products.

In a horizontally differentiated product, Neven (1986) replaces the uniform distribution of customer preferences assumption with increasing densities of consumers towards the center of the attribute space. He shows when the distribution of customers is not concentrated, firms should maximally differentiate, as in the case of uniform density. However, for more concentrated customers' distributions, firms should follow a minimum differentiation strategy and locate towards the center.

Assuming a vertically differentiated product and symmetric triangular distribution of consumer preferences, Tabuchi and Thisse (1995) demonstrate that there is no symmetric equilibrium. However, they characterize asymmetric equilibria (partial differentiation) in pure strategies for such consumers' preference distributions.

2.2.2.2. Multi-attribute Product Differentiation

The economics (Lancaster, 1966) and psychology (Fishbein, 1963) literatures view products as attribute bundles, with heterogeneous customer preferences across attributes. When firms differentiate on multiple attributes, their positioning strategy can range from no differentiation on any attribute, to maximal differentiation on all attributes, or anywhere in between (e.g. to fully differentiate on one attribute while offering the same levels on others, or to partially differentiate on some attributes).

Considering a product with *n* horizontal attributes, Irmen and Thisse (1998) conclude that in equilibrium firms should not maximally differentiate on all attributes. Instead, they should maximally differentiate on the dominant attribute with minimum differentiation on all other attributes (i.e., Max-Min differentiation). Assuming one horizontal and one vertical attribute, Neven and Thisse (1990) conclude that firms should not maximally differentiate on both dimensions (Max-Max). Instead, they find that differentiation should pursue a Max-Min strategy on either attribute, but fail to prove that those equilibria are the only ones.

Vandenbosch and Weinberg (1995) propose a model with two vertical attributes and identify conditions leading to various types of market differentiation equilibria: Max-Min, Partial-Max, and Max-Max. Lauga and Ofek (2011) extend (Vandenbosch & Weinberg, 1995) analysis to consider increasing marginal costs as quality increases. They identify three types of equilibria, which are conditional on the magnitude of marginal costs for different quality levels. When the quality level marginal costs are relatively higher, firms should follow Max-Max (or partial-Max) strategies, where one firm offers the highest quality levels on both attributes, while the other firm chooses the lowest

possible levels. When the quality provision marginal costs are lower, firms should maximally differentiate on one attribute, while offering the same quality level on the other attribute (Max-Min equilibrium). The quality level on which firms agglomerate is the highest (lowest) possible quality level, when the quality provision costs are relatively low (intermediate).

Assuming a generalized beta distribution for customers' preferences, Ansari et al. (1994) conclude that even a small change in distribution of preferences may significantly change the product pricing and positioning equilibria of the firms. In particular, for relatively homogenous preferences (concentrated distributions) asymmetric product position equilibria are determined where one firm choses a corner position in the market, while the other locates at an interior position (partial differentiation).

2.3. Contributions of the Dissertation Research

The literature review reveals an increasing interest in CSR with researchers investigating various aspects of strategic CSR. This research is one of the few studies that proposes an analytical duopoly model for determining product differentiation or product positioning strategies. Our research is unique in that it simultaneously addresses the impact of SR product induced changes on marginal supply costs, market growth in ordinary and SR market segments, and brand image, and the interactions among these factors, on the firms' decisions to offer an SR or N product. These model features yield a more comprehensive model of SR product differentiation and product positioning than in the literature. In addition, our model specifications consolidate several factors previously treated in isolation into a comprehensive model (see Table 1). This research makes unique and important contributions to the research literature and management practice.

3. Research Methodology: Product Differentiation Model and Solution Procedure

Table 2 summarizes the notation used in the model development.

Table 2 Parameters and Decision Variables

Symbol	Definition
c^N	Marginal cost of providing non-SR product
c^{SR}	Marginal cost of providing SR product
D_j	Total demand of firm *j*
p_j	Price for firm *j*'s product
B_j	Location of firm *j*'s brand
SR_j	Firm *j's* decision of commitment to SR products: 1 if commits, 0 otherwise
α	Relative size of the hardcore to ordinary market segment
v^O	Ordinary customer's reservation utility
v^H	Hardcore SR customer's reservation utility
θ_i^{SR}	Consumer *i*'s willingness to pay for the product social attribute
θ_i^B	Consumer *i*'s location of ideal brand
t	Disutility per unit deviation of non-SR product's brand image from the ideal brand
t^{SR}	Disutility per unit deviation of SR product's brand image from the ideal brand
γ	Halo/Horns coefficient

3.1.Model Development

Consider two firms, indexed $j \in (1, 2)$, competing in a duopolistic market based on product offering, brand image and price. Each firm offers one of two product variants differentiated by their level of social responsibility: SR product and non-SR (N) product. SR is a vertical attribute where, assuming all other factors equal, all consumers prefer products with a higher level of SR, but are heterogeneous in their willingness-to-pay for the SR attribute. Brand image (B_j), a horizontal attribute, is a composite blend of consumer perceptions of the product portfolio and service offerings of firm *j*. Since each firm's brand image is established, the immediate competition hinges on whether the firm(s) should offer the SR product, recognizing that offering the SR product can impact brand image and ultimately sales.

All customers belong to either the ordinary market segment (*O*) with market size n_O or the hardcore SR market segment (*H*) of size n_H. Hardcore consumers do not value the N product and only purchase the SR product. The market growth opportunity for offering the SR product is $\alpha = \frac{n_H}{n_O}$, where without loss of generality, we normalize $n_O = 1$ with α being the proportional increase.

The market is heterogeneous such that each consumer *i* differs in her willingness-to-pay for the premium priced SR attribute (θ_i^{SR}) and the location of their ideal brand (θ_i^B). We assume customer preferences θ_i^{SR} and θ_i^B are independent and uniformly distributed over [0, 1]. Thus, as illustrated in Figure 1, consumers are uniformly distributed in the product attribute space, where the intervals [0, 1] form a unit square. Consumer *i* is located at $(\theta_i^{SR}, \theta_i^B)$. The firms are horizontally differentiated on brand image, where firms 1 and 2 are located at $B_1 = 0$ and $B_2 = 1$, respectively.

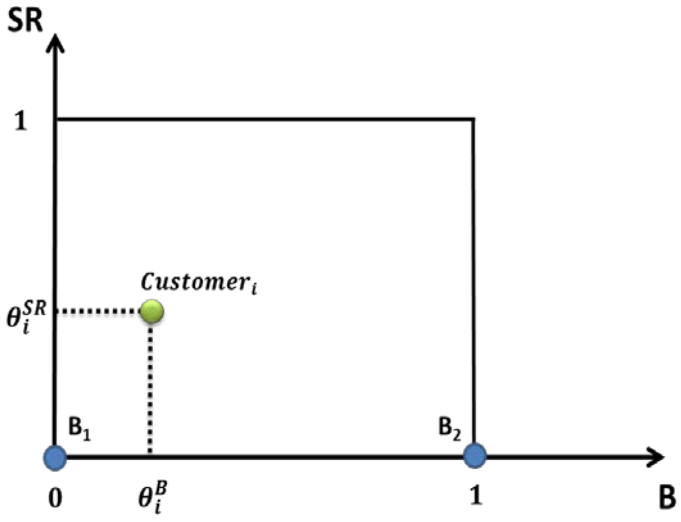


Figure 1 Potential Locations of Firms and Customers in the Product Attribute Space

Ordinary customer *i* incurs brand-image disutility of $t\,|\theta_i^B - B_j|$ if she buys the N product from firm *j*, or $t^{SR}\,|\theta_i^B - B_j|$ if she buys the SR product, where $|\theta_i^B - B_j|$ is perceived distance of consumer *i*'s ideal brand image from firm *j*'s brand image. The parameters *t* and t^{SR} represent the disutility per unit deviation from the ideal brand image[3]. The *halo/horns coefficient*, $\gamma = t - t^{SR}$, captures the impact of the SR product offering on the firms' brand image. With all other factors being equal, $\gamma > 0$ indicates that offering the SR product has a positive ("halo") effect on the firm's brand image, while $\gamma < 0$ implies a negative (horns) effect.

Ordinary customer *i*'s utility for buying an *N* or *SR* product from firm *j* at price p_j is given by $U_{i,j}^{O,N}$ or $U_{i,j}^{O,SR}$, respectively:

$$U_{i,j}^{O,N} = v^O - t\,|\theta_i^B - B_j| - p_j, \tag{1}$$

$$U_{i,j}^{O,SR} = v^O + \theta_i^{SR} - t^{SR}\,|\theta_i^B - B_j| - p_j. \tag{2}$$

Hardcore customer *i*'s utility for the N product is $U_{i,j}^{H,N}$=0, and $U_{i,j}^{H,SR}$ for SR product:

$$U_{i,j}^{H,SR} = v^H + \theta_i^{SR} - t^{SR}\,|\theta_i^B - B_j| - p_j. \tag{3}$$

The reservation utilities, v^O and v^H, (which are common to all consumers in the market segment) are sufficiently high so that each consumer buys either the *N* or *SR* product, unless the SR product isn't offered, in which case the hardcore customers don't purchase a product.

[3] This disutility is referred to as "transportation cost" in Hotelling's linear city models.

3.2. Model Solution

The model follows a two-stage game. In Stage 1, each firm chooses whether to offer an *SR* or an *N* product with marginal costs of c^{SR} and c^{N}, respectively. Possible outcomes of Stage 1 subgame are: both firms offer an N product (N/N); both offer an SR product (SR/SR); or one firm offers the SR product and the other offers the N product (SR/N*)*. In Stage 2, aware of the rival's Stage 1 decision, each firm maximizes its profit, $\pi_j = D_j(p_j - c_j)$, by observing its demand, D_j, and setting its product price. Finally, each consumer buys one unit from the firm that maximizes her utility.

The model is analyzed using backward induction by solving the pricing and product offering decisions sequentially. In Step 1, we determine the pricing decisions in subgame equilibria for each potential outcome of Stage 1. We begin by finding the locations of indifferent customers; that is, the consumers who perceive equal utility from purchasing the product from either firm. The set of indifferent customers forms a straight line in the product attribute space and marks the boundary separating SR and N product demand. Applying calculus identifies each firm's demand, D_j , as a function of p_1 and p_2. Next, the pricing equilibria for each outcome scenario is determined by jointly maximizing the firms' profits, which yields each firm's equilibrium prices, demands and profits for that scenario.

In Step 2, we solve the Stage 1 problem, where the firms decide whether or not to offer the SR product, contingent on the equilibrium prices derived in Step 1.

4. Equilibrium Analysis

This chapter presents the Stage 2 subgame pricing equilibrium for each possible Stage 1 outcome, followed by Stage 1 product offering analysis given the pricing equilibrium results.

4.1. Pricing Equilibrium

In the pricing subgame, the choice of the SR or N product by each firm is known. Thus, we are interested in the price competition that follows. We begin with the benchmark scenario, N/N, where neither firm offers the SR product.

4.1.1. N/N Scenario: Both Firms Offer an N Product

This scenario establishes the benchmark for offering the SR product. Since only the N product is offered, hardcore SR consumers do not purchase in this scenario. Competition in this scenario is based on the firms' brand images and price.

First, we set $U_{i,j}^{O,N} = U_{i,-j}^{O,N}$ and solve for the location of the indifferent customers, θ_{ind}^{B}, i.e., they have equal utility when purchasing from either firm *j* or firm *–j*, resulting in:

$$\theta_{ind}^{B} = \frac{1}{2} + \frac{p_j - p_{-j}}{2t}. \qquad (4)$$

Subsequently, the demand for firm *j*'s product, D_j, is a function of the selling prices:

$$D_j = \frac{1}{2} - \frac{p_j - p_{-j}}{2t}. \qquad (5)$$

Jointly maximizing both firm's profits yields the equilibrium prices $p_N^{N/N}$, demands, $D_N^{N/N}$ and profits, $\pi_N^{N/N}$. The results are stated in Lemma 1. Please see A1.1 in the Appendix for detailed derivation of all results.

LEMMA 1. In the N/N scenario both firms have symmetric equilibrium prices, $p_N^{N/N} = t + c^N$*, market demand,* $D_N^{N/N} = \frac{1}{2}$ *and profit,* $\pi_N^{N/N} = \frac{t}{2}$.

4.1.2. SR/SR: Both Firms Offer an SR Product

In the SR/SR scenario, both firms offer the SR product, thereby penetrating the hardcore SR market segment and increasing total market size to 1 + α. We assume the firms cannot practice differential pricing between market segments. As such, the SR product price is identical in both market segments, but may vary across firms.

As in the N/N scenario, we first find the location of the indifferent customers, where:

$$\theta_{ind}^{B} = \frac{1}{2} + \frac{p_j - p_{-j}}{2\, t^{SR}}. \qquad (6)$$

The demand for firm *j*'s product demand in the SR/SR scenario is written as a function of the firms' prices:

$$D_j = \left(\frac{1}{2} - \frac{p_j - p_{-j}}{2t^{SR}}\right)(1 + \alpha). \qquad (7)$$

Jointly maximizing the firms' profits yields the equilibrium prices, demands and profits given in Lemma 2. Please see A1.2 in the Appendix for detailed derivation of all results.

LEMMA 2. In the SR/SR scenario, both firms have symmetrical equilibrium prices, $p_{SR}^{SR/SR} = t^{SR} + c^{SR}$*, market demand,* $D_{SR}^{SR/SR} = \frac{1+\alpha}{2}$ *and profit* $\pi_{SR}^{SR/SR} = \frac{t^{SR}(1+\alpha)}{2}$.

Comparison of the equilibria prices for the two symmetrical scenarios, N/N and SR/SR, reveals firms' profit margins per customer are equal to t and t^{SR}, respectively. These findings indicate the contribution of brand image to the firms' profits, and the impact of offering the SR product on profits. Specifically, when $\gamma = t - t^{SR} > 0$, the SR product's halo effect on the SR firms' brand image decreases brand differentiation and profits, while the horns effect ($\gamma < 0$) increases brand differentiation and profits[4]. In general, horizontally differentiated firms should seek to distance themselves by brand image.

In order to compensate for the decline in profit margins associated with the halo effect in the SR/SR scenario, the size of the hardcore market segment should make up for the reduced profit margin per consumer. That is, only if $\alpha > \frac{\gamma}{t^{SR}}$, then $\pi_{SR}^{SR/SR} > \pi_{N}^{N/N}$.

4.1.3. SR/N: One Firm Offers an SR and the Other Offers an N Product

In the asymmetric SR/N scenario, the SR firm offers the SR product and the N firm offers the N product. The SR firm serves the hardcore SR market segment, while both firms compete in the ordinary market segment.

[4] Hotelling (1929) found a similar result in his linear city model, where lowering transportation cost per unit decreased the impact of distance on competition and the equilibria profits.

The set of ordinary customers who are indifferent between buying the SR and N products forms a linear line in the product attribute space. Solving for the location of indifferent customers yields:

$$\theta_{ind}^{SR} = (t + t^{SR})\theta_{ind}^{B} + p_{SR}^{SR/N} - p_{N}^{SR/N} - t. \quad (8)$$

In the unit square defining the ordinary consumers' market segment, consumer *i*, located at $(\theta_i^B, \theta_i^{SR})$, buys the N product, if $\theta_i^{SR} < \theta_{ind}^{SR}(\theta_i^B)$; otherwise, the consumer buys the SR product. The N-firm's demand, $D_N^{SR/N}$, is calculated by integrating the $\theta_{ind}^{SR}(\theta_i^B)$ function over its domain. The SR-firm's demand includes its share of the ordinary market segment plus the hardcore market segment, which yields:

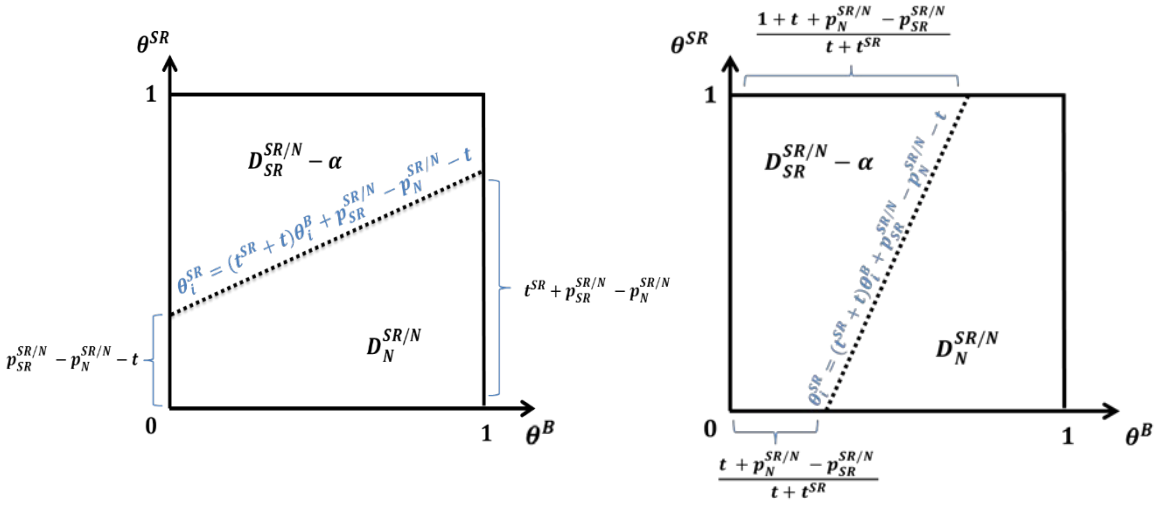
$$D_{SR}^{SR/N} = 1 - D_N^{SR/N} + \alpha. \quad (9)$$

Based on the problem's parameter settings, the position and slope of the indifferent consumers' line, and consequently each firms' demand, may vary. We consider two conditions: vertical dominance and horizontal dominance.

Vertical dominance indicates that consumers are more sensitive to the changes in product's SR attribute than changes in brand image. Vertical dominance is depicted in Figure 2.a where the indifferent customers' line crosses the vertical sides of the unit square. That is, when the absolute value of the slope of the consumers' indifferent-line is less than one (i.e., $|\frac{\partial \theta_{ind}^{SR}}{\partial \theta^B}| < 1$), or equivalently $t + t^{SR} < 1$.[5]

[5] Assuming that firms can chose the level of their products' social responsibility, SR_j, the vertical dominance case happens when $2t - \gamma(SR_1 + SR_2) < |SR_1 - SR_2|$. Similarly, $2t - \gamma(SR_1 + SR_2) > |SR_1 - SR_2|$ justifies the horizontal dominance case.

Horizontal dominance occurs when consumers are more sensitive to the changes in brand image than changes in product's SR attribute. In this case, the consumers' indifferent-line crosses the horizontal sides of the unit square as illustrated in Figure 2.b. Horizontal dominance exists when $|\frac{\partial \theta_{ind}^{SR}}{\partial \theta^{B}}| > 1$, or equivalently $t + t^{SR} > 1$.

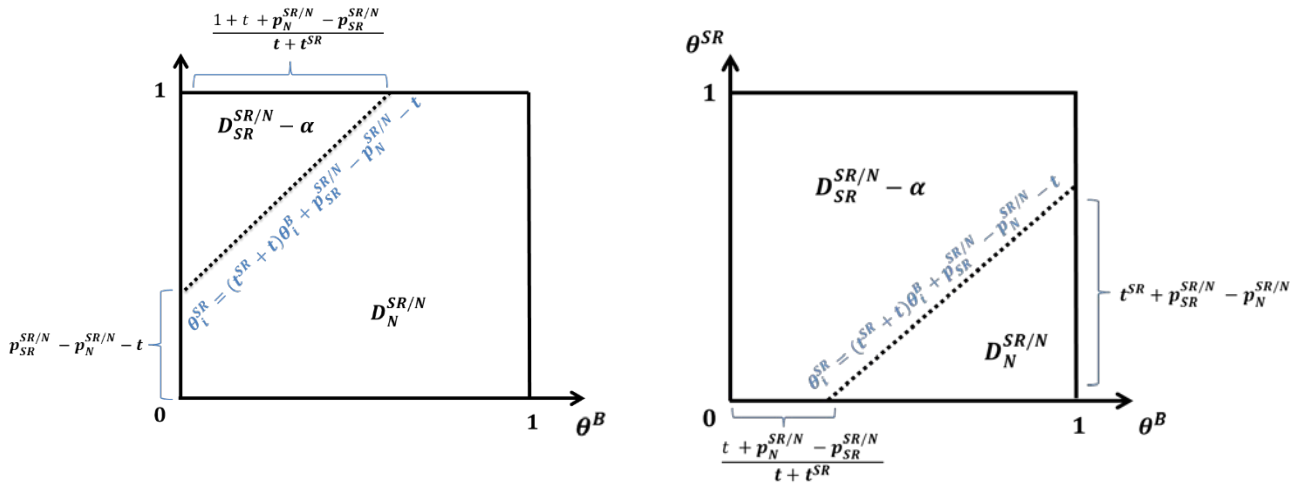


(a) Vertical Dominance **(b) Horizontal Dominance**

Figure 2 Ordinary Market Demand under Vertical and Horizontal Dominance Conditions in SR/N Scenario

For the vertical dominance case, it is readily verified in Figures 2.a that, ceteris paribus, decreasing $p_{SR}^{SR/N}$ or increasing $p_N^{SR/N}$, will shift the consumers' indifference-line ($\theta_{ind}^{SR} = (t + t^{S})\theta_{ind}^{B} + p_{SR}^{SR/N} - p_N^{SR/N} - t$) vertically towards the bottom side of the unit square. This reduces the N-firm's demand. For sufficiently low values of $p_{SR}^{SR/N}$ the consumers indifference-line ultimately crosses the bottom and right sides of the unit square as the N-firm continually loses market share (see Figure 3.b). Conversely, increasing $p_{SR}^{SR/N}$, shifts the consumers' indifference-line up until the indifference line

crosses the top and left sides of the unit square (see Figure 3.a). At the extreme, the N-firm captures the entire ordinary customer market, leaving the SR-firm to serve the hardcore market segment in a quasi-monopoly situation. A similar situation occurs under horizontal dominance, where the consumers' indifference-line shifts left with an increase in $p_{SR}^{SR/N}$ or decrease in $p_N^{SR/N}$ and vice versa.



(a) Upper Triangle **(b) Lower Triangle**

Figure 3 Special Cases of the Ordinary Market Demand in SR/N scenario

For the SR/N scenario, we determine the existence regions and pricing equilibria as a function of model parameters (α, t, t^{SR}, c^N, and c^{SR}) for each of the six types of demand structures (i.e., three demand structures for both horizontal and vertical dominance). The analysis is provided in A1.3 section of the Appendix.

LEMMA 3. In the SR/N asymmetric scenario, six types of unique pricing equilibria may arise. The prices, demands, and profits for the six equilibria as well as their existence conditions are given in Table 3.

Table 3 Characteristics of the Six Pricing Equilibria under SR/N Scenario

Equilibria Type	Characteristics
	Vertical Dominance: $t + t^{SR} < 1$
Eq^{V1} (Lower Triangle)	Existence conditions: $0 \leq c^{SR} \leq 2t + t^{SR} - \alpha - 1$
	$p_{SR}^{SR/N} = \frac{3(c^{SR} + X^{LT}) - 5t^{SR}}{8}$
	$p_{N}^{SR/N} = \frac{t^{SR} + c^{SR} + X^{LT}}{8}$
	$D_{SR}^{SR/N} = \frac{12(\alpha+1)(t + t^{SR}) - (t^{SR} + c^{SR})^2 - (t^{SR} + c^{SR})X^{LT}}{16(t + t^{SR})}$
	$D_{N}^{SR/N} = \frac{(t^{SR} + c^{SR} + X^{LT})^2}{32(t + t^{SR})}$
	$\pi_{SR}^{SR/N} = \frac{[18(\alpha+1)(t + t^{SR}) + (t^{SR} + c^{SR})^2]X^{LT} + (t^{SR} + c^{SR})^3 - 42(\alpha+1)(t + t^{SR})(t^{SR} + c^{SR})}{16(t + t^{SR})}$
	$\pi_{N}^{SR/N} = \frac{(t^{SR} + c^{SR} + X^{LT})^3}{256(t + t^{SR})}$
Eq^{V2}	Existence conditions: Max $(0, 2t + t^{SR} - \alpha - 1) \leq c^{SR} \leq 2 - t - 2t^{SR} - \alpha$
	$p_{SR}^{SR/N} = \frac{2\alpha + 2c^{SR} + 2}{3} + \frac{t - t^{SR}}{6}$
	$p_{N}^{SR/N} = \frac{\alpha + c^{SR} + 1}{3} - \frac{t - t^{SR}}{6}$
	$D_{SR}^{SR/N} = \frac{2(\alpha+1) - c^{SR}}{3} + \frac{t - t^{SR}}{6}$
	$D_{N}^{SR/N} = \frac{(\alpha+1) + c^{SR}}{3} - \frac{t - t^{SR}}{6}$
	$\pi_{SR}^{SR/N} = \frac{1}{9}\left[2(\alpha+1) + \frac{t - t^{SR}}{2} - c^{SR}\right]^2$
	$\pi_{N}^{SR/N} = \frac{1}{9}\left[(\alpha+1) - \frac{t - t^{SR}}{2} + c^{SR})\right]^2$
Eq^{V3} (Upper Triangle)[6]	Existence conditions: $c^{SR} \geq 2 - t - 2t^{SR} - \alpha$
	$p_{SR}^{SR/N} = \frac{(7 - 3\alpha)c^{SR} + (1 - 5\alpha)(t + 1) + X^{UT2}}{8(1 - \alpha)}$
	$p_{N}^{SR/N} = \frac{X^{UT1} - (5 - \alpha)(t + 1 - c^{SR})}{8(1 - \alpha)}$
	$D_{SR}^{SR/N} = \frac{32\alpha(t + t^{SR}) + [t + 1 - c^{SR} + X^{UT1} - X^{UT2}]^2}{32(t + t^{SR})}$
	$D_{N}^{SR/N} = \frac{32(t + t^{SR}) - [t + 1 - c^{SR} + X^{UT1} - X^{UT2}]^2}{32(t + t^{SR})}$
	$\pi_{SR}^{SR/N} = \frac{[X^{UT2} + (t + 1 - c^{SR})(1 - 5\alpha)][32\alpha(t + t^{SR}) + [t + 1 - c^{SR} + X^{UT1} - X^{UT2}]^2]}{256(t + t^{SR})(1 - \alpha)}$
	$\pi_{N}^{SR/N} = \frac{[X^{UT1} - (t + 1 - c^{SR})(5 - \alpha)][32(t + t^{SR}) - [t + 1 - c^{SR} + X^{UT1} - X^{UT2}]^2]}{256(t + t^{SR})(1 - \alpha)}$

[6] The equations characterize the inner equilibrium solution. Please see Appendix for more details.

Horizontal Dominance: $t + t^S > 1$

Eq^{H1} (Lower Triangle)

Existence conditions: $0 \leq c^{SR} \leq 2 - t - 2t^{SR} - \alpha(t + t^{SR})$

Equilibrium configurations are the same as Eq^{V1} (Lower Triangle)

Eq^{H2}

Existence conditions: $Max(0, 2 - t - 2t^{SR} - \alpha(t + t^{SR})) \leq c^{SR} \leq 2t + t^{SR} - \alpha(t + t^{SR}) - 1$

$$p_{SR}^{SR/N} = \frac{2[\alpha(t + t^{SR}) + t + c^{SR}] + t^{SR}}{3} + \frac{1}{6}$$

$$p_N^{SR/N} = \frac{\alpha(t + t^S) + t + c^{SR} + 2t^{SR}}{3} - \frac{1}{6}$$

$$D_{SR}^{SR/N} = \frac{2\alpha}{3} + \frac{4t + 2(t^{SR} - c^{SR}) + 1}{6(t + t^S)}$$

$$D_N^{SR/N} = \frac{\alpha}{3} + \frac{4t^S + 2(t + c^S) - 1}{6(t + t^S)}$$

$$\pi_{SR}^{SR/N} = \frac{[2\alpha(t + t^{SR}) + 2t + t^{SR} - c^{SR} + \frac{1}{2}]^2}{9(t + t^{SR})}$$

$$\pi_N^{SR/N} = \frac{[\alpha(t + t^{SR}) + t + 2t^{SR} + c^{SR} - \frac{1}{2}]^2}{9(t + t^{SR})}$$

Eq^{H3} (Upper Triangle)

Existence conditions: $c^{SR} \geq 2t + t^{SR} - \alpha(t + t^{SR}) - 1$

Equilibrium configurations are the same as Eq^{V3} (Upper Triangle)

Note. Where $c^N = 0$, $X^{LT} = \sqrt{(t^{SR} + c^{SR})^2 + 8(\alpha + 1)(t + t^{SR})}$,

$X^{UT1} = \sqrt{(t + 1 - c^{SR})^2(5 - \alpha)^2 + 8(1 - \alpha)[(\alpha + 3)^2(t + t^{SR}) - 2(t + 1 - c^{SR})^2]}$

X^{UT2}

$= \sqrt{[(7 - 3\alpha)c^{SR} + (1 - 5\alpha)(t + 1)]^2 + 8(1 - \alpha)[(3\alpha + 1)^2(t + t^{SR}) - 6(c^{SR})^2 + 2\alpha(t + 1)^2 + (6\alpha - 2)(t + 1)c^{SR}]}$

4.2.Product Equilibrium

We now consider Stage 1 problem where the firms decide whether to offer the SR product, contingent upon the equilibrium prices of the Stage 2 subgame. The matrix below indicates the pay-offs associated with each decision set.

		Firm -j	
		N product	SR product
Firm j	N product	$\pi_N^{N/N}, \pi_N^{N/N}$	$\pi_N^{SR/N}, \pi_{SR}^{SR/N}$
	SR product	$\pi_{SR}^{SR/N}, \pi_N^{SR/N}$	$\pi_{SR}^{SR/SR}, \pi_{SR}^{SR/SR}$

The expressions $\pi_N^{N/N}$, $\pi_{SR}^{SR/SR}$, $\pi_{SR}^{SR/N}$, and $\pi_N^{SR/N}$ are given in Lemmas 1-3 for the N/N, SR/SR and SR/N scenarios, respectively. We are interested in finding product positioning strategies equilibrium under different market conditions. A strategy set is an equilibrium if neither firm can improve profit by unilateral deviation from the specified strategy.

Our model is unique as it considers the marginal costs increase, market growth, and changes to brand perception associated with offering the SR product. First, we isolate the impact of marginal costs increase and market growth to build the intuition behind our general results. Then we provide the results of our general model.

First, we analyze product equilibrium when the marginal costs for the N and SR product are equal. Without loss of generality we set $c^N = c^{SR} = 0$. Please see A2.1 in the Appendix for the proof of Proposition 1, including the $\overline{\alpha}(t, t^{SR})$ threshold value.

PROPOSITION 1. Suppose $c^N = c^{SR} = 0$*.Under both Vertical, and Horizontal Dominance conditions, when the potential market growth is relatively small (*$\alpha < \bar{\alpha}(t, t^{SR})$*) both firms offer the SR product.*[7] *When the potential market growth is relatively large (*$\alpha > \bar{\alpha}(t, t^{SR})$*) one firm offers the SR product and the other offers the N product.*

There are several points to note about Proposition 1. First, as common intuition suggests, When $c^N = c^{SR} = 0$, the N/N equilibrium does not exist since at least one of the firms will offer the SR product. The consumers' willingness-to-pay a premium for the SR product, enables the SR firm to set a higher price and increase its share of the ordinary market segment. In addition, the SR firm will penetrate the hardcore SR market segment.

The second point, which can be counter intuitive, is that when $\alpha < \bar{\alpha}(t, t^{SR})$, both firms offer SR products; however, when $\alpha > \bar{\alpha}(t, t^{SR})$, only one firm offers the SR product. Intuitively, offering an SR product should be more profitable when larger portion of customers are hardcore, and seemingly more firms should offer the SR product. This counterintuitive finding can be explained by the competition dampening revenue effect. That is, when both firms offer the SR product they are only differentiated based on their brands, and experience more intense price competition within a shared market (ordinary and hardcore segment). However, when the hardcore segment is large enough, firms have this incentive to further differentiate along the SR dimension to reduce the price competition. The SR firm exclusively serves the hardcore segment and

[7] When t^{SR} is very low there is no such equilibrium where both firms offer SR products. See the appendix for more details.

reduces its share from the ordinary customers by setting higher prices, while the other firm sets lower prices to increase its share of ordinary customers.

We next consider the case with increasing marginal costs of offering the SR product, where $c^{SR} > c^{N} = 0$, or equivalently c^{SR} is the marginal cost increase. We assume $\alpha = 0$ in order to isolate the impact on the marginal cost increase. Please see A2.1 in the Appendix for the proof of Proposition 2, including the lower and upper marginal cost increase thresholds, $\underline{c}(t, t^{SR})$ and $\overline{c}(t, t^{SR})$.

PROPOSITION 2. Suppose $\alpha = 0$ *and* $c^{SR} > c^{N} = 0$.*Under both Vertical, and Horizontal Dominance conditions, when the increase in the marginal cost of offering SR product is high* ($c^{SR} > \overline{c}(t, t^{SR})$)*, both firms offer N product. When the marginal cost increase is intermediate* ($\underline{c}(t, t^{SR}) < c^{SR} < \overline{c}(t, t^{SR})$) *one firm offers SR product and the other offers N product. Finally, when the increase is low* ($c^{SR} < \underline{c}(t, t^{SR})$) *both firms offer SR product.*

There are several points to note about Proposition 2. First, as common intuition suggests, when the cost of offering the SR product is considerably higher than the N product, and $\alpha = 0$, neither firm has the incentive to offer the SR product. Note that the SR firm has to set higher prices ($p_{SR}^{SR/N} \geq c^{SR} \geq p_{N}^{SR/N}$), which results in losing ordinary customers to the N firm.

When the increase in the marginal cost of offering SR products is intermediate, $\underline{c}(t, t^{SR}) < c^{SR} < \overline{c}(t, t^{SR})$, one firm has the incentive to offer the SR product, as the increase in price is compensated by a large set of customers' willingness-to-pay a premium for the SR attribute. Price competition is less intense due to product

differentiation on the SR attribute and the higher cost of the SR product which prevents the SR firm from lowering its prices to capture the entire market.

Finally, when the marginal cost increase is below the lower threshold, i.e. $c^{SR} < \underline{c}(t, t^{SR})$, both firms offer SR products to maintain market share. Nevertheless, when the SR attribute has a halo effect on brand image, each firm's profit margin per consumer is lower in the SR/SR than N/N equilibrium since $t > t^{SR}$. Thus, assuming that there is no potential market growth in the hardcore market segment, i.e., $\alpha = 0$, both firms realize lower profits in SR/SR equilibrium compared to the N/N equilibrium. This implies the firms are locked in a prisoner's dilemma; that is, if a firm unilaterally deviates from the SR/SR strategy, it will be worse off. We further discuss this condition in Proposition 4.

We next analyze our general model that includes the effects of marginal costs increase, potential market growth, and changes to brand perception associated with offering the SR product and their interactions. For convenience, the notations $\overline{\alpha}(t, t^{SR})$, $\underline{c}(t, t^{SR})$, $\overline{c}(t, t^{SR})$, $f_{Lead}(c^{SR}, t, t^{SR})$ and $f_{Follow}(c^{SR}, t, t^{SR})$ are defined in A2.1 in the Appendix. For given *t* and t^{SR} values, Proposition 3 is illustrated in Figure 4 for all values of c^{SR} and α.

PROPOSITION 3. Suppose $\alpha \geq 0$ *and* $c^{SR} \geq c^{N} = 0$.*Under both Vertical, and Horizontal Dominance conditions, when* $c^{SR} > \overline{c}(t, t^{SR})$ *and* $\alpha < f_{Lead}(c^{SR}, t, t^{SR})$ *both firms offer the N product (N/N). When* $c^{SR} < \underline{c}(t, t^{SR})$ *and* $\alpha < f_{Follow}(c^{SR}, t, t^{SR})$ *both firms offer the SR product (SR/SR). Otherwise, one firm offers the SR product and the other offers the N product (SR/N), given any of the following conditions:*

(i) $c^{SR} > \overline{c}(t, t^{SR})$ *and* $\alpha > f_{Lead}(c^{SR}, t, t^{SR})$,

(ii) $c^{SR} < \underline{c}(t, t^{SR})$ *and* $\alpha > f_{Follow}(c^{SR}, t, t^{SR})$,

(iii) $\underline{c}(t, t^{SR}) < c^{SR} < \overline{c}(t, t^{SR})$,*and*

(iv) $\alpha > \bar{\alpha}(t, t^{SR})$.

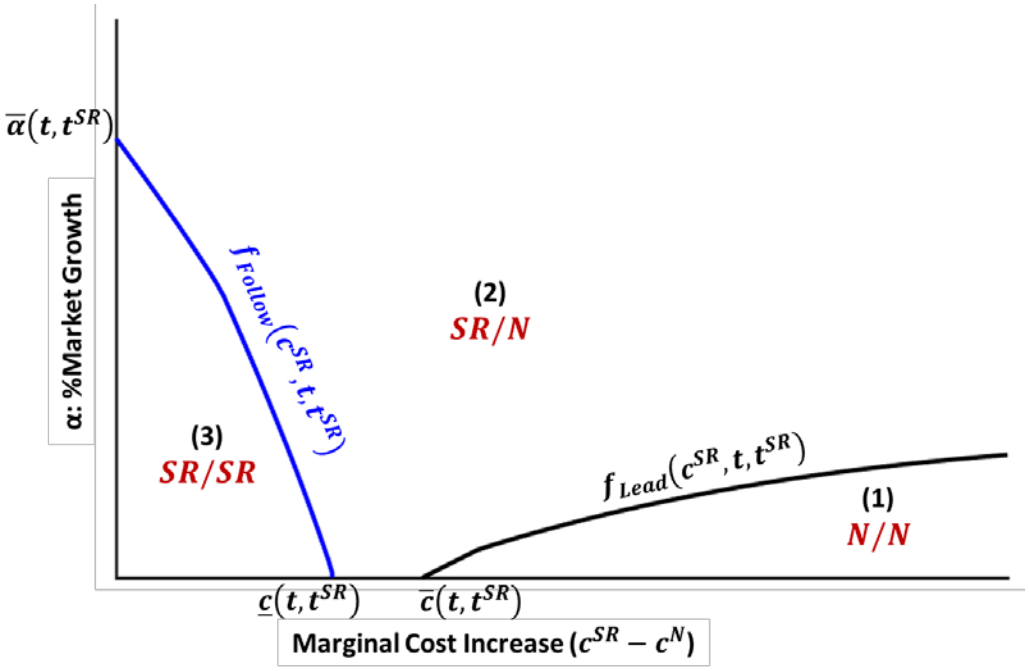


Figure 4 Boundary Conditions for Product Positioning Equilibria at Specified t and t^{SR} Values

Proposition 3 is unique in showing the market conditions under which firms offer SR products. Prior studies relevant to this research do not consider the effects of marginal cost increase, potential market growth due to the SR hardcore segment, and brand image changes due to SR product offerings, simultaneously. Specifically, earlier studies assume $c^{SR} = c^{N} = 0$, $\alpha = 0$, and/or $t = t^{SR}$, which are special cases of the general model in Proposition 3.

Using N/N equilibrium in region (1) of Figure 4 as the benchmark, we consider two types of incentives that lead firms to adopt other strategy sets, namely SR/N and

SR/SR, as shown in regions (2) and (3) of Figure 4. The first one relates to a firm's incentive to *lead* the development of the SR product, given that its competitor offers the N product, i.e. $\pi_{SR}^{SR/N} - \pi_{N}^{N/N} > 0$. The second relates to a firm's incentive to *follow* the development of the SR product, given that its competitor offers the SR product, i.e. $\pi_{SR}^{SR/SR} - \pi_{N}^{SR/N} > 0$. Here the terms *lead* and *follow* are only used to describe a firm's best response to the competitor's anticipated decision while the game is played simultaneously.

As described in Proposition 2, when the marginal cost of offering the SR product is considerably higher than the N product, and the potential market growth is small, none of the firms offer an SR product. This market condition is illustrated as region (1) in Figure 4, where both lead and follow incentives are negative ($\pi_{N}^{N/N} > \pi_{SR}^{SR/N}$ and $\pi_{N}^{SR/N} > \pi_{SR}^{SR/SR}$). Moving towards region (2) market conditions, that is lower marginal costs and/or larger ratios of hardcore segment, the *lead* incentive increases. Finally, by passing the threshold labeled as $f_{Lead}(c^{SR}, t, t^{SR})$ in Figure 4 ($\pi_{SR}^{SR/N} - \pi_{N}^{N/N} = 0$ contour), the *lead* incentive becomes positive and one firm develops the SR product while the other firm develops the N product (asymmetric positioning strategy).

Both firms set high prices and enjoy their highest profits in the top-right corner of region (2), where both the SR marginal cost increase and the potential market growth are at their highest levels. Under such market conditions, firms act as Quasi-Monopolies: the SR firm mainly serves the higher SR oriented customers, while the N firm focuses on the ordinary segment (Upper Triangle demand shape illustrated in Figure 3-b), which lessens price competition. The high marginal cost of the SR product prevents the SR firm to set

lower prices, which results in loss of the ordinary market segment to the N firm. The N firm earns higher profit due to lower marginal cost and larger market share.

Moving towards the bottom-left corner of region (2), both firms earn lower profits and face more intense price competition. Smaller hardcore segment and lower marginal cost incentivize the SR firm to lower its prices and thus increase his share of the ordinary market segment. Both firms earn lower profits compared to the former quasi-monopoly condition, but the N firm's profit loss is higher. Finally, by passing the threshold labeled as $f_{Follow}(c^{SR}, t, t^{SR})$ in Figure 4 ($\pi_{SR}^{SR/SR} - \pi_{N}^{SR/N} = 0$ contour), the *follow* incentive becomes positive, and the N firm also commits to the SR product to prevent further loss.

Propositions 1–3 identify when and how the three factors associated with offering an SR product - marginal costs increase, potential market growth, and changes to brand perception – lead to market conditions where one, both, or none of the firms will offer an SR product. Table 4 summarizes the results of Propositions 1–3. Next we identify how these three factors affect the profitability of developing an SR product.

Table 4 Equilibrium Strategies under Different Market Conditions

		Marginal cost increase ($c^{SR} - C^{N}$)		
		Low	***Intermediate***	***High***
Relative size of the hardcore segment (α)		$c^{SR} < \underline{c}(t, t^{SR})$	$\underline{c}(t, t^{SR}) < c^{SR} < \overline{c}(t, t^{SR})$	$c^{SR} > \overline{c}(t, t^{SR})$
	Small $\alpha < \bar{\alpha}(t, t^{SR})$	*SR/SR*	*SR/N*	*N/N*
	Large $\alpha > \bar{\alpha}(t, t^{SR})$	*SR/N*	*SR/N*	*SR/N*

4.3.Profit implications of Developing SR Products

Below we examine the profit implications of firms developing SR products. By comparing the equilibrium profits in our model, where firms have the option of developing SR products, to the profit in a benchmark model where firms only offer standard products. Offering the SR product can result in three different profit outcomes for competing firms as discussed in Proposition 4: Win-Win (W-W), Win-Lose (W-L) and Lose-Lose (L-L).

PROPOSITION 4. Under both Vertical and Horizontal Dominance conditions, when compared to the benchmark N/N:

i. *(Win-Win) When the SR attribute has a horns effect on brand image ($t < t^{SR}$) both firms benefit when either one or both offer an SR product (Figure 5-a).*

   When the SR attribute has a halo effect on brand image ($t > t^{SR}$):

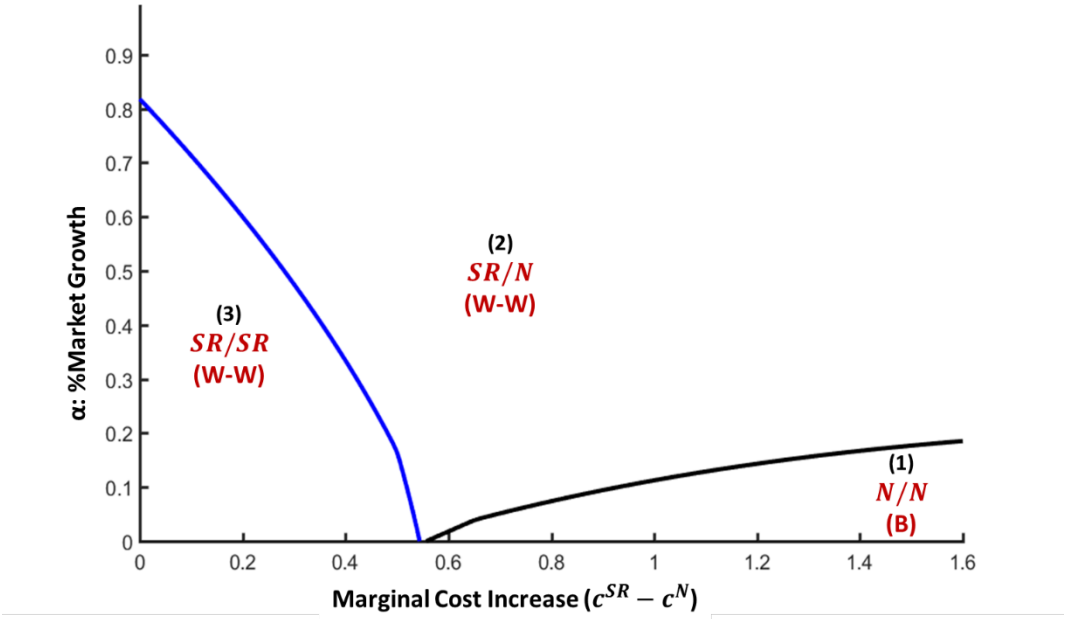
ii. *(Win-Win) Under SR/N conditions described in Proposition 3, when the price competition is relatively less intense ($g(\alpha, c^{SR}, t, t^{SR}) > 0$), both SR and N firms benefit from the asymmetric product positioning strategy (region 2.1 in Figure 5-b).*

iii. *(Win-Lose) Under SR/N conditions described in Proposition 3, when the price competition is relatively more intense ($g(\alpha, c^{SR}, t, t^{SR}) < 0$), the SR firm benefits and the N firm loses from the asymmetric product positioning strategy (region 2.2 in Figure 5-b).*

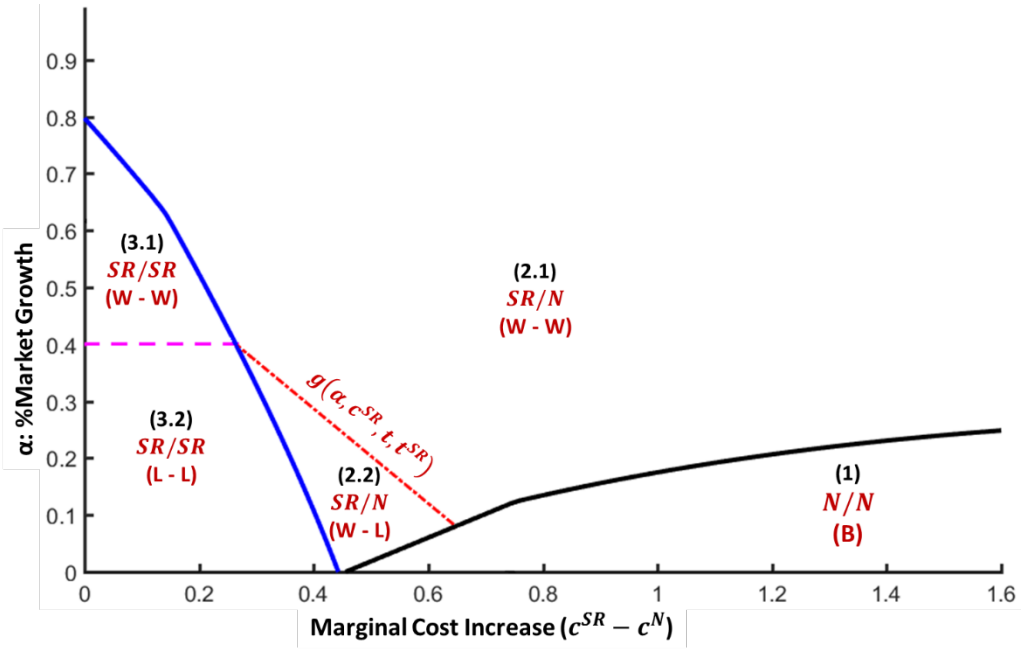
iv. *(Win-Win) Under SR/SR conditions described in Proposition 3, when the potential market growth is large enough ($\alpha > \frac{t-t^{SR}}{t^{SR}}$) both firms offer and benefit from SR product development (region 3.1 in Figure 5-b).*

v. *(Lose-Lose) Under SR/SR conditions described in Proposition 3, when the potential market growth is not large enough ($\alpha < \frac{t-t^{SR}}{t^{SR}}$) both firms offer SR products despite profit loss, that is a Prisoner's Dilemma condition (region 3.2 in Figure 5-b).*

Proof of proposition 4 and the derivation of the threshold value $g(\alpha, c^{SR}, t, t^{SR})$ can be found in Appendix A2.2. Proposition 4 distinguishes the profit implications of offering SR products for two general conditions: when the SR attribute has a horns effect on brand perception (case *i*) versus a halo effect (cases *ii* to *v*). Under horns effect, both firms earn higher profits when either one or both offer an SR product, but this is not the case under halo effect. This can be counter intuitive, as one may expect higher firm profits under halo effect since customers realize less disutility for deviating from their ideal brand ($t^{SR} < t$). This is explained by observing that the reduction of disutility for deviating from ideal brand means that the customers are placing less weight on firms' differentiation based on brand image. In other words, customers become more (less) price sensitive under halo (horns) effect condition, which leads to a more (less) intense price competition between firms. For example, when customers associate organic products with being healthier, having better taste, and/or higher quality, then *buying organic*, becomes their dominant purchase criteria. They will buy the cheapest *organic* product, putting little value on the brand or other product attributes.



(a) Boundary Conditions under Horns Effect ($t = 0.5,\ t^{SR} = 0.7$)



(b) Boundary Conditions under Halo Effect ($t = 0.7, t^{SR} = 0.5$)

Figure 5 Profit Implications of Offering SR Products

Figure 5-a shows the profit implications of offering SR products when the SR attribute has a negative (horns) effect on brand perception (case *i*), and Figure 5-b shows the profit implications under halo effect conditions (cases *ii* to *v*).

Case *(ii)* in Proposition 4 shows how competing firms can both benefit from differentiation in SR dimension. As explained in proposition 3, firms receive their highest profits by following asymmetric SR strategy and acting as quasi-monopolies, where majority of the ordinary segment customers are served by the non-SR firm, while the SR firms mainly serves the hardcore segment. Price competition is less intense under such market conditions (region 2.1 in Figure 5-b) for two reasons: 1- High marginal cost of SR products which prevents the SR firm to set low prices; and 2- Large hardcore customer segment which compensates the SR firm's loss of ordinary consumers. These two forces reduce the price competition between firms. Therefore, the intensity of price competition is at its minimum in the top-right corner of region (2.1), where both SR marginal cost and hardcore segment ratio are at their highest levels. Consequently, firms set higher prices and enjoy more profits under such market condition.

Due to the dynamics described in Case *(ii)*, both firms realize more intense price competition and earn lower profits, by moving towards the bottom-left corner of region (2.1), until we pass the $g(\alpha, c^{SR}, t, t^{SR}) = 0$ threshold and enter the Case *(iii)* market conditions (region (2.2) in Figure 5-b). Lower marginal cost allows, and smaller hardcore segment incentivize the SR firm to set lower prices and to increase his market share from the ordinary segment. It should be noted that both firms earn lower profits when moving from the top-right corner of region (2.1) towards the bottom-left corner of region (2.2) market conditions. However, the non-SR firm's profit drops at a higher rate. In fact, the

SR firm still "wins" and enjoys higher profits compared to the N/N benchmark, while the non-SR firm "loses" from this asymmetric SR strategy.

Cases (iv) and (v) in Proposition 4 show the market conditions where both *lead* and *follow* incentives are positive, as explained under proposition 3. The non-SR firm also chooses offering SR product under this market conditions to prevent further profit loss. Firms are no longer differentiated on SR dimension, so they realize more intense price competition and earn less profit compared the asymmetric SR strategy equilibrium. Compared to the N/N benchmark, however, proposition 4 shows depending on market conditions, following SR/SR strategy can result in increased or diminished profitability for firms (case *(iv)* and case *(v)* respectively).

Notice that two factors drive firm's profit: 1- profit margin per consumer; 2- market size (number of customers). Compared to N/N equilibrium, under halo effect condition, firms' profit margin per consumer drops in SR/SR equilibrium. However, firms enjoy larger market size by offering SR products and absorbing hardcore SR segment. In the following we explain in more details how trade-offs between profit margin reduction and market size increase leads to increased or diminished profitability for firms.

Case *(v)* in Proposition 4 shows that although both firms are free to choose offering standard products, in equilibrium both firms choose offering SR products and are worse off. In particular, this is the first research that shows that competing firms may offer SR products while it results in a clear profit loss for both firms. In other words, Case *(v)* shows that the competing firms can be locked in a prisoner's dilemma by offering SR products. This happens because firms are not cooperating in setting their

strategy. Under case (*v*) market conditions, both firms would benefit from offering standard products. However, should one firm choose to offer standard product, the other firm could benefit greatly by offering SR product, which imposes huge loss to the non-SR firm. Therefore, in order to prevent further expected loss, both firms offer SR products but are worse off.

It should be noted that despite common intuition, the profit-reduction result in case *(v),* is not mainly due to the marginal cost increase of offering SR products. In fact, Lemma 2 results show that both firms are able to set their prices high enough to account for the additional cost of offering SR products ($p_{SR}^{SR/SR} = t^{SR} + c^{SR}$). The profit-reduction is rather due to the positive (halo) effect of SR attribute on brand perception. As explained earlier, buying from a specific brand is less important and customers are more price sensitive under halo effect condition. Therefore, a relatively small increase in the product price may lead customers to switch buying from the rival. That means price competition between firms is more intense under halo effect condition. Notice that based on Lemma 1 and Lemma 2 results, firms' profit margins per consumer under N/N and SR/SR equilibria are *t* and t^{SR}, respectively. Therefore, under halo effect condition (i.e., when $t^{SR} < t$), firms' profit margin per consumer drops. While by absorbing hardcore consumer segment firms enjoy larger market size under SR/SR equilibrium, this market growth is not enough to compensate the drop in the profit margin. Therefore, both firm experience profit loss under case *(v)* market conditions.

Finally, case *(iv)* in Proposition 4 shows market conditions where following SR/SR strategy can increase the firms' profitability. Due to the dynamics described in Case *(v)* both firms experience lower profit margins per consumer. However, reduced margins are

compensated by the increase in the market size, resulted from absorbing a large enough hardcore market segment. Based on Lemma 1 and Lemma 2 results, in order to have enough market growth to compensate for the profit margin drops, we should have: $\alpha > \frac{t-t^{SR}}{t^{SR}}$, where α is the relative size of the hardcore segment to ordinary segment. This is the threshold between region 3.1 and 3.2, illustrated in Figure 5-b.

One immediate managerial implication of Proposition 4 is that, when competitive firms consider developing SR products, they need to consider both the expected market growth and the (possible) strategic profit margin reduction. Specifically, under halo effect condition, where consumers are more price sensitive, firms should be cautious that offering SR products could intensify price competition and lead to a significant profit margin reduction. Thus, measures to increase market size by offering SR products can have an unintentional consequence of profit loss.

4.4. SR Products and Economic Welfare

Propositions 3 and 4 present conditions for offering SR and/or N products along with profit implications for duopolistic firms, but do not capture the impact of product offering decisions on the consumers' welfare. Lemma 4 presents consumers' utility conditions with additional details in section A3 of the Appendix.

LEMMA 4. Total consumers' utility for all possible pricing equilibria types and their existence conditions are presented in Table 5.

Table 5 Total Consumers' Utility under Different Pricing Equilibria

Equilibria Type	**Total Consumers' Utility: $CU^T = CU^O + CU^H$**
N/N	$CU^O = v^O - 1.25\,t\,,\ CU^H = 0$
SR/SR	$CU^O = v^O + 0.5 - c^{SR} - 1.25\,t^{SR},\ CU^H = \alpha(v^H + 0.5 - c^{SR} - 1.25\,t^{SR})$
	SR/N: Vertical Dominance: $t + t^{SR} < 1$
Eq^{V1} (Lower Triangle)	Existence conditions: $0 \le c^{SR} \le 2t + t^{SR} - \alpha - 1$ $p_{SR}^{SR/N} = \frac{3(c^{SR} + X^{LT}) - 5t^{SR}}{8}$, $p_N^{SR/N} = \frac{t^{SR} + c^{SR} + X^{LT}}{8}$ $CU^O = v^O - p_{SR}^{SR/N} + 0.5 * (1 - t^{SR} + \frac{b^3}{3(t + t^{SR})} + b(t + t^{SR}) + b^2 + \frac{(t + t^{SR})^2}{3})$ $CU^H = \alpha(v^H + 0.5 - p_{SR}^{SR/N} - 0.25\,t^{SR})$
Eq^{V2}	Existence conditions: Max $(0, 2t + t^{SR} - \alpha - 1) \le c^{SR} \le 2 - t - 2t^{SR} - \alpha$ $p_{SR}^{SR/N} = \frac{2\alpha + 2c^{SR} + 2}{3} + \frac{t - t^{SR}}{6}$, $p_N^{SR/N} = \frac{\alpha + c^{SR} + 1}{3} - \frac{t - t^{SR}}{6}$ $CU^O = v^O - p_{SR}^{SR/N} + 0.5 * (1 - t^{SR} + b^2 + b(t + t^{SR}) + \frac{(t + t^{SR})^2}{3})$ $CU^H = \alpha(v^H + 0.5 - p_{SR}^{SR/N} - 0.25\,t^{SR})$
Eq^{V3} (Upper Triangle)	Existence conditions: $c^{SR} \ge 2 - t - 2t^{SR} - \alpha$ $p_{SR}^{SR/N} = \frac{(7 - 3\alpha)c^{SR} + (1 - 5\alpha)(t + 1) + X^{UT2}}{8(1 - \alpha)}$, $p_N^{SR/N} = \frac{X^{UT1} - (5 - \alpha)(t + 1 - c^{SR})}{8(1 - \alpha)}$ $CU^O = v^O - p_N^{SR/N} - \frac{t}{2} + \frac{(1 - b)^3}{6(t + t^{SR})}$, $CU^H = \alpha(v^H + 0.5 - p_{SR}^{SR/N} - 0.25\,t^{SR})$
	SR/N: Horizontal Dominance: $t + t^S > 1$
Eq^{H1} (Lower Triangle)	Existence conditions: $0 \le c^{SR} \le 2 - t - 2t^{SR} - \alpha(t + t^{SR})$ Equilibrium configurations are the same as Eq^{V1} (Lower Triangle)
Eq^{H2}	Existence conditions: $Max(0, 2 - t - 2t^{SR} - \alpha(t + t^{SR})) \le c^{SR} \le 2t + t^{SR} - \alpha(t + t^{SR}) - 1$ $p_{SR}^{SR/N} = \frac{2[\alpha(t + t^{SR}) + t + c^{SR}] + t^{SR}}{3} + \frac{1}{6}$, $p_N^{SR/N} = \frac{\alpha(t + t^s) + t + c^{SR} + 2t^{SR}}{3} - \frac{1}{6}$ $CU^O = v^O - p_N^{SR/N} - \frac{t}{2} + \frac{b^2 - b + 1/3}{2(t + t^{SR})}$, $CU^H = \alpha(v^H + 0.5 - p_{SR}^{SR/N} - 0.25\,t^{SR})$
Eq^{H3} (Upper Triangle)	Existence conditions: $c^{SR} \ge 2t + t^{SR} - \alpha(t + t^{SR}) - 1$ Equilibrium configurations are the same as Eq^{V3} (Upper Triangle)

Note. Where $c^N = 0$, $b = p_{SR}^{SR/N} - p_N^{SR/N} - t$, $X^{LT} = \sqrt{(t^{SR} + c^{SR})^2 + 8(\alpha + 1)(t + t^{SR})}$,

$X^{UT1} = \sqrt{(t + 1 - c^{SR})^2(5 - \alpha)^2 + 8(1 - \alpha)[(\alpha + 3)^2(t + t^{SR}) - 2(t + 1 - c^{SR})^2]}$,

$X^{UT2} = \sqrt{[(7 - 3\alpha)c^{SR} + (1 - 5\alpha)(t + 1)]^2 + 8(1 - \alpha)[(3\alpha + 1)^2(t + t^{SR}) - 6(c^{SR})^2 + 2\alpha(t + 1)^2 + (6\alpha - 2)(t + 1)c^{SR}}$

Total consumers' utility, CU^T, is the sum of the customer utilities of the ordinary and hardcore market segments; i.e. $CU^T = CU^O + CU^H$. Under each market equilibrium, higher values of c^{SR} decrease CU^O, CU^H and thus CU^T is lower since $\frac{\partial CU^T}{\partial C^{SR}}, \frac{\partial CU^O}{\partial C^{SR}}, \frac{\partial CU^H}{\partial C^{SR}} < 0$. As shown earlier in Lemma 1-3, both N and SR firms set higher prices when c^{SR} increases resulting in reduced utility for all consumers. Figure 6 illustrates the total consumers' utility in equilibria as compared to its value in the N/N benchmark case. As can be seen in Figure 6, total consumers' utility reduces exponentially by moving towards the top-right corner of graph, where both SR marginal cost and hardcore segment ratio are at their highest levels. As explained under Proposition 3 and 4, that is the Quasi-Monopoly situation where firms experience the least price competition and set their prices to the highest level.

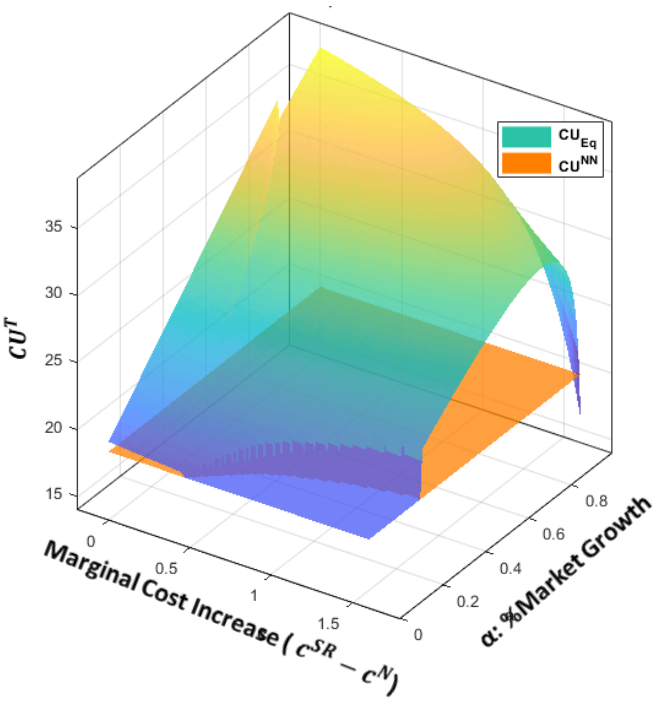


Figure 6 Total Consumers' Utility ($t = 0.7, t^{SR} = 0.5$)

It is also important to consider the *economic welfare, i.e.,* the sum of consumers' utility and producers' (firms') surplus[8] at product equilibrium, based on the results from Lemma 1-4 and Proposition 3. *Corollary 1* below presents *economic welfare* conditions for all the types of product equilibria.

Corollary 1. Economic Welfare, EW, for all possible equilibria types, under vertical or horizontal dominance conditions are as follows (given $\alpha \geq 0$ *and* $c^{SR} \geq c^{N} = 0$*):*

(N/N) When both firms offer N product, $c^{SR} > \overline{c}(t, t^{SR})$ *and* $\alpha < f_{Lead}(c^{SR}, t, t^{SR})$*:*

$$EW^{N/N} = CU^{T} + 2\pi_{N}^{N/N}$$

(SR/SR) When both firms offer SR products, $c^{SR} < \underline{c}(t, t^{SR})$ *and* $\alpha < f_{Follow}(c^{SR}, t, t^{SR})$*:*

$$EW^{SR/SR} = CU^{T} + 2\pi_{SR}^{SR/SR}$$

(SR/N) When one firm offers the SR and the other the N product:

$$EW^{SR/N} = CU^{T} + \pi_{SR}^{SR/N} + \pi_{N}^{SR/N}$$

When compared to the *N/N* benchmark case, *economic welfare* in equilibria does not vary dramatically under different market conditions as can be seen in Figure 7. This is explained by the shift of benefits between the consumers and the firms as conditions changes. For instance, in the top right corner of Figure 9, where there is a quasi-monopoly situation, despite the exponential reduction in consumer utility, the change in

[8] A consumer's surplus is the positive difference between the maximum price a consumer is willing to pay and the actual price he pays, whereas a producer's surplus is the difference between the selling price and the production cost (profit).

economic welfare is incremental since the consumer utility reduction is replaced by the gain in the firms' utility.

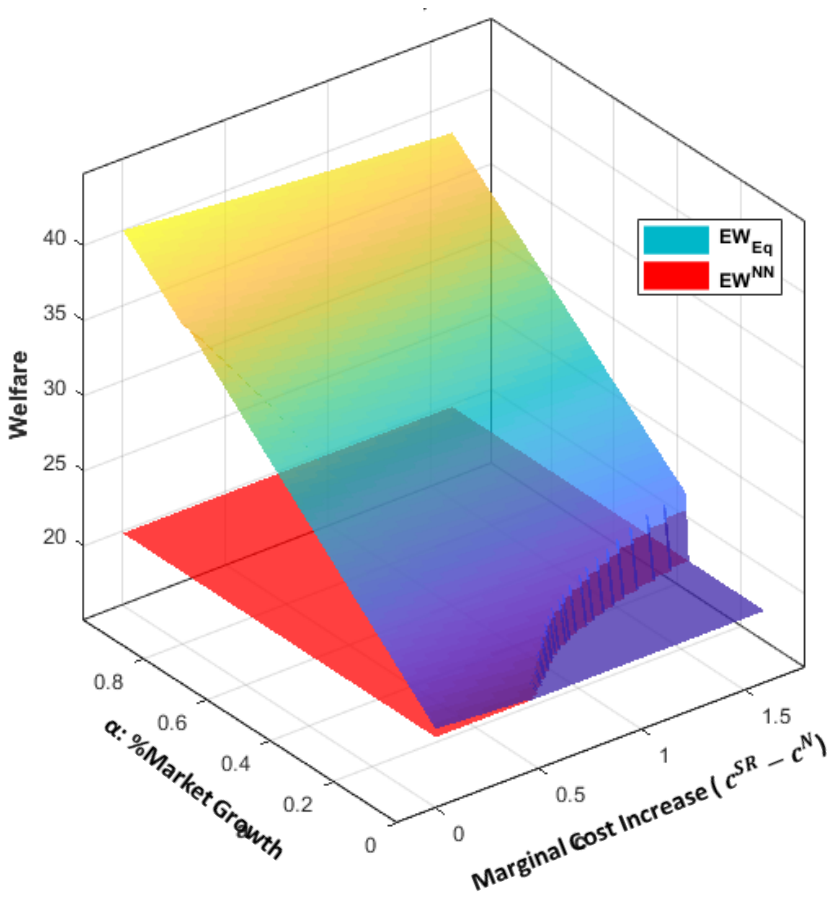


Figure 7 Economic Welfare ($t = 0.7, t^{SR} = 0.5$)

5. Other Factors

5.1. Fixed Costs for SR Product Development

In product development, in addition to variable cost, there is often a fixed cost associated with new technology investment, research and development, and other factors. In this section, we extend the general model to include a fixed cost associated with developing the SR product. The profit function, π_j, is modified to capture such a cost, where F_j represents the fixed cost for firm *j*:

$$\pi_j = D_j(p_j - c_j) - F_j$$

Our interest is mainly in the cost of developing an SR product and its impact on profit. As such, the fixed cost associated with an *N* product, F^N is normalized at zero, whereas the fixed cost of developing an *SR* product, F^{SR}, is the incremental fixed cost of developing an SR product beyond the *N* product fixed costs.

The model analysis shows that considering the SR product's fixed cost does not affect the pricing subgame results as the firms' best response functions remain the same. Equilibrium prices in Lemma 1-3 remain unchanged with the inclusion of fixed costs while $\pi_{SR}^{SR/N}$ and $\pi_{SR}^{SR/SR}$ values are lowered by F^{SR}.

The baseline model of Proposition 3 remains robust when the fixed cost of SR product development is considered with the exception of the threshold values of $f_{Lead}(c^{SR}, t, t^{SR})$ and $f_{Follow}(c^{SR}, t, t^{SR})$ shifting slightly downward and subsequently reducing the values of $\overline{\alpha}(t, t^{SR})$, $\underline{c}(t, t^{SR})$ and $\overline{c}(t, t^{SR})$. Figure 8 illustrates the impact of F_{SR} with the shifting threshold values, where the *N/N* region expands while the *SR/SR*

region contracts. The finding is intuitive in that offering an *SR* product is more costly than an *N* product.

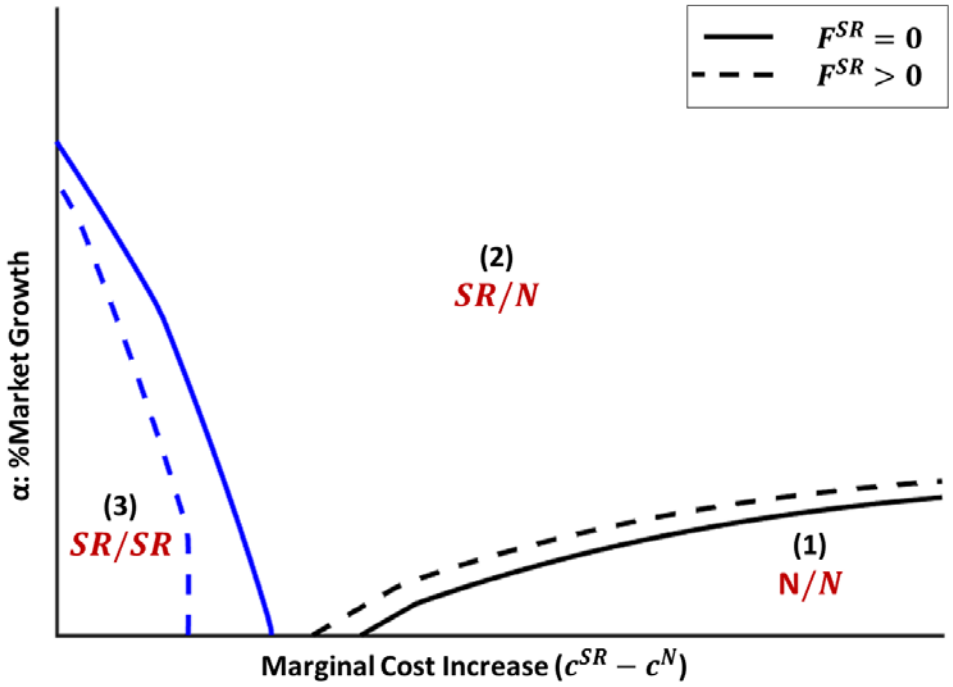


Figure 8 Equilibria Implications of Considering SR Development Fixed Costs

5.2. Innovator – Follower Game

We now consider an innovator-follower version of our main model. In this extension, the competing firms are differentiated where only one firm acts as the innovator and leads the SR product development while the other firm is the follower and can only offer the SR product if the leader offers it. This assumption is particularly well-suited for market conditions, where SR product development requires significant investment in infrastructure, technology and know-how. In this case, the follower firm often needs substantial lead time for resource acquisition and deployment before offering

the SR product. Development of hybrid electric vehicles (HEV) provides an example. Toyota introduced the Prius in 1997 in Japan as the leader in the HEV market. It took several years until other auto manufacturers could introduce a similar product. The timing of decisions for the innovator and the follower, and the subsequent profits are summarized in Figure 9.

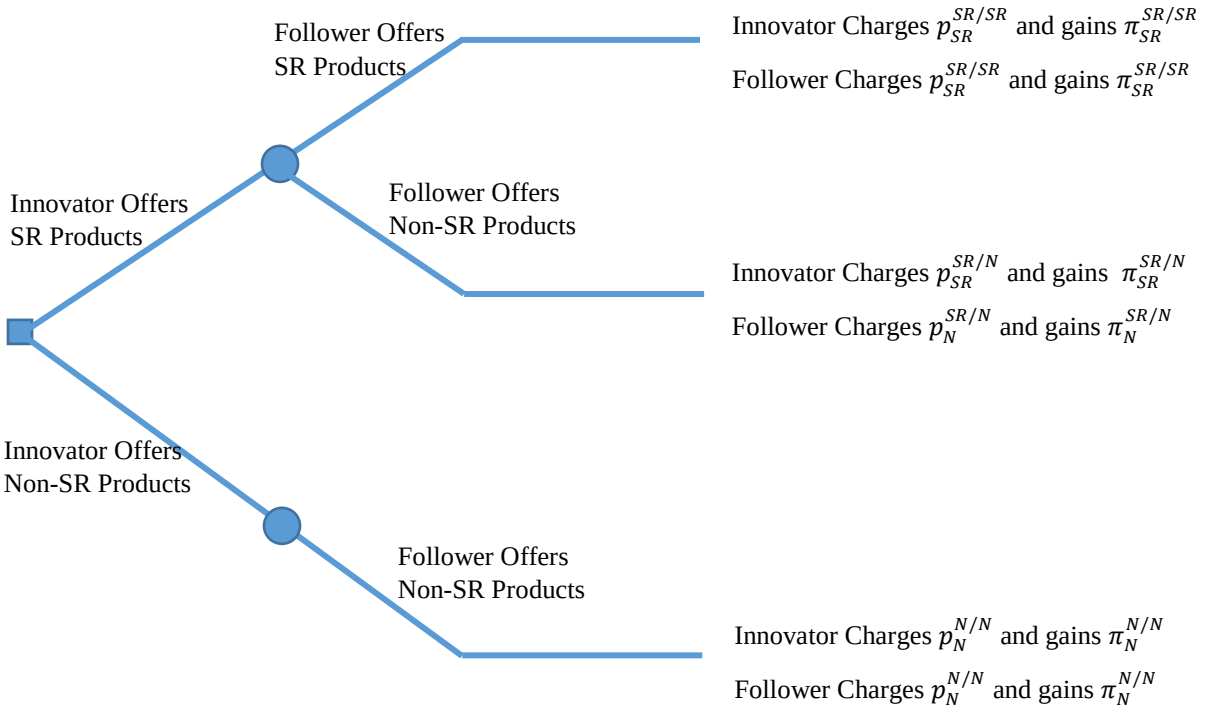


Figure 9 Timing of Innovator-Follower Game

The model is solved by using backward induction. In stage 1, pricing subgame for each combination of firms' product offering strategies is solved. The results show that the equilibrium prices, demands and profits for each combination of firm strategies remain

the same as those in Lemma 1-3. Then in stage 2, given each of the innovator's potential product strategy, the follower's optimal product offering strategy is determined. Finally, the innovator's optimal strategy is determined based on the expected reactions of the follower. Results of the innovator-follower game are summarized in Proposition 5.

Proposition 5. In an innovator-follower model, under vertical or horizontal dominance conditions:

i. *(N/N): Under N/N market conditions described in Proposition 3, or part of the SR/SR region where the hardcore segment is not large enough ($\alpha < \frac{t-t^{SR}}{t^{SR}}$), both firm offer N product (region 1 and 3.2 in Figure 5-b).*
ii. *(SR/SR): Under SR/SR market conditions described in Proposition 3, when the hardcore segment is large enough ($\alpha > \frac{t-t^{SR}}{t^{SR}}$), both firm offer SR products. (region 3.1 in Figure 5-b)*
iii. *(SR/N): Under SR/N conditions described in Proposition 3, the innovator firm offers SR product, and the follower offers N product.*

The results of Proposition 5 shed light on why an innovator may choose to offer the N product despite having the capability to offer an SR product. When an innovator realizes that the rival has the sophistication to initiate an SR product development, he may choose not to sell an SR product in order to avoid a possible price competition and loss of profit, namely the Prisoner's dilemma. The only exception is when the hardcore market segment is large enough, where both firms can offer the SR product and still be in a winning position as in part (ii) of Proposition 5.

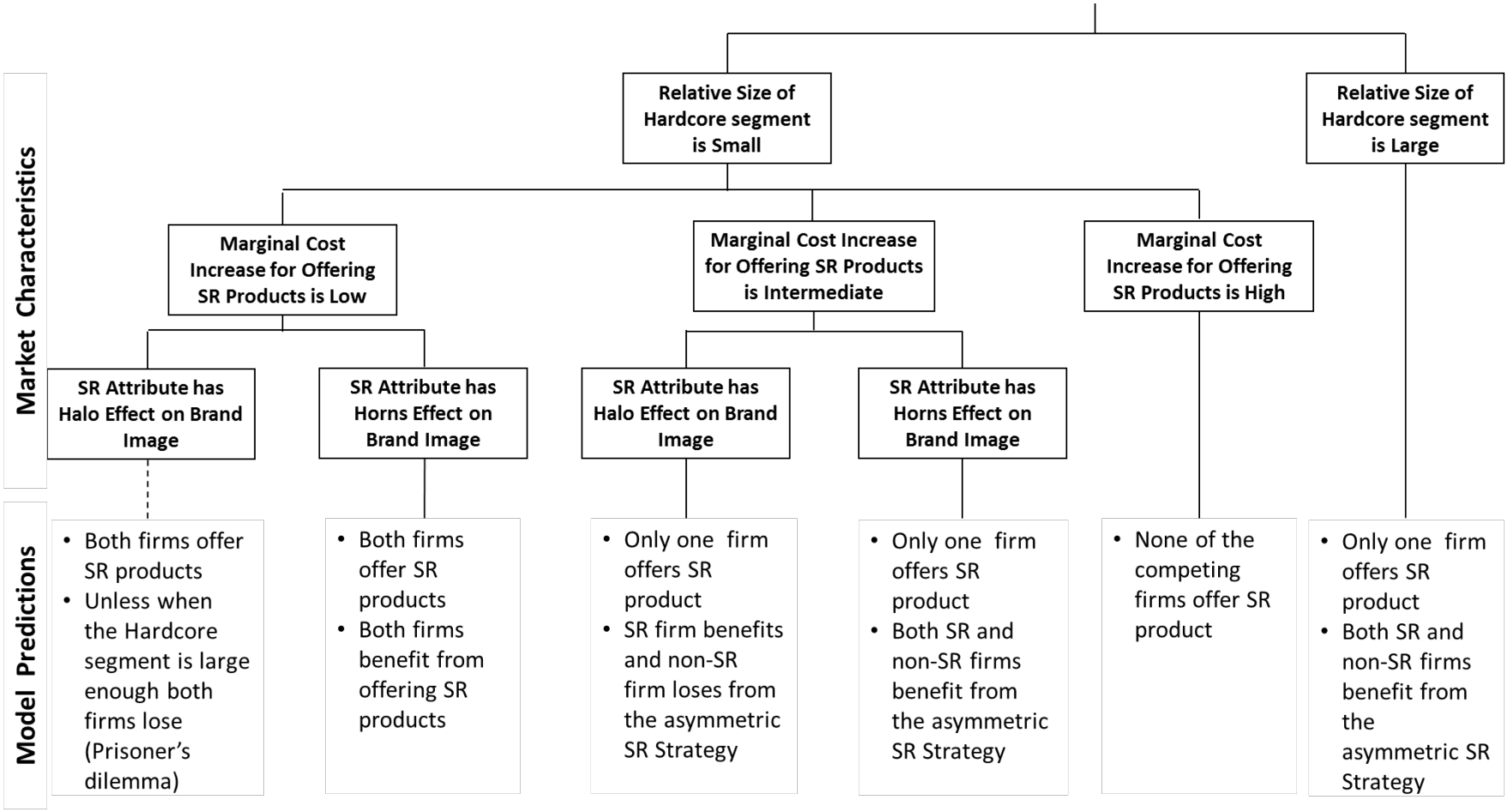
In asymmetric product offering strategy, i.e. SR/N scenario, findings are consistent with those in Propositions 4 and 5 and the innovator has the first mover advantage from offering the SR product.

6. Discussion and Conclusion

6.1. Summary and Managerial Implications

Our study examines the strategic implications of firms using social responsibility as a product differentiation mechanism in the marketplace. While the extant literature examines isolated factors impacting socially responsible (SR) product development, we propose an integrated model that shows how firms' commitment to SR products depend on the associated marginal costs increase, potential market growth, and changes to brand perception. Moreover, while the empirical findings regarding relationship between CSR and corporate financial performance (CFP) are mixed, see e.g. (Servaes & Tamayo, 2013), our study provides a clear roadmap as to when developing SR products will increase, maintain, or diminish a firm's profitability. Therefore, our findings have important managerial implications for firms considering SR commitments in competitive markets.

In isolation, CSR initiatives and offering SR product might improve firm profitability through improved brand image, market growth, and consumers' willingness to pay a premium for SR attribute. However, when offering an SR product is recognized as a new product positioning and differentiation mechanism, it can trigger market response from competitors, and such competitive effects can diminish profitability. We summarize the managerial implications of this study in Figure 10, which can serve as a framework for enabling managers to better assess the consequences of developing SR products. In order to use this framework, managers should use market research to address following questions.



Notes: Model predictions apply to both the base model and innovator-follower extension, with an execption indicated by the dashed line: in the innovator-follower extension, no firm offers SR products unless benefits from it.

Figure 10 Model Predictions

1. What is the expected size of the hardcore SR consumer segment that the firm can capture, relative to the size of the ordinary consumer segment?
2. How great is the marginal cost increase of offering SR product?
3. Does the SR attribute have a positive (halo) or negative (horns) effect on the consumers' brand perception?
4. Does the rival firm have the requisite capabilities for independently launching an SR product?

The model predictions are also beneficial for managers in identifying their target market and setting their marketing plans, or to understand those of their rivals. For example, the *hardcore SR market segment* should be the target market of a firm that offers SR products in the quasi-monopoly market condition as described in Proposition 3 (upper-right areas of rigion 2 in Figure 4). Developing niche supply chains for SR products are very costly. However, as the model suggests, these firms can offset those costs by premium pricing, and attracting dedicated SR customers. Patagonia outdoor clothing and Dr. Bronner's personal care products are examples of deeply entrenched socially responsible companies. Still the majority of companies offer SR products in market conditions depicted in the lower-left areas of region 2 or reagion 3 of Figure 4. For these firms, while gaining share in the hardcore SR market segment is part of their marketing plans, their initial priority is to increase penetration in their *ordinary market segment*. As our results indicate, price competition is intense under these market conditions and offering SR product can in fact be a survival strategy, where firms' must offer the SR product to remain competitive. McDonald's commitment to cage-free eggs and its ripple effect in the industry is an example of such SR initiatives.

Finally, common intuition may suggest that a SR product development strategy would be less profitable as the marginal cost of offering SR products increases. In other words, firms tend to invest in less costly SR initiatives in anticipation of higher profits. However, our research findings show that the higher costs of offering SR products may increase the profitability of the competing firms by relaxing the price competition. Also, we show that it is *competitive pressure,* rather than profitability, that pushes the firms to engage in less costly SR development initiatives, even such activities might decrease profits.

6.2. Limitations and Future Research

Our analysis and findings are limited to the scope of model, as restricted by several assumptions. First, we considered two symmetric firms competing in a duopoly. In reality, often multiple firms with different market powers and capabilities may compete in the market. It would be useful to examine whether the model findings extend to the case of oligopoly or pure competition. We expect that the N/N and SR/SR equilibria -- where all firms offer standard or SR products, respectively -- would hold for some regions, but the quasi-monopoly setting under SR/N equilibrium disappear, as more firms enter the profitable market.

Second, in our model firms choose to offer either standard or SR products. In practice, some firms may decide to offer multiple products with different levels of social responsibility. In this case, the SR attribute could be modeled as a continuous or a multi-level variable, rather than a dichotomous variable. Firms might minimally differentiate on SR attribute and agglomerate on each end of SR spectrum by offering the lowest or the highest possible levels of the SR attribute (equivalent to N/N and SR/SR strategies in our

model). Alternatively, firms might maximally differentiate on SR dimension (equivalent to the SR/N equilibrium), or partially differentiate, where one firm offers a product with intermediate level of SR attribute. We leave the examination of these extensions for future research.

Third, we assume that the consumers' reservation value for buying the product is sufficiently high, such that they all buy in equilibrium, guaranteeing that the market is fully covered. The full market coverage assumption can be relaxed by giving the consumers an option to opt out of the market or to buy from the fringe firms (see e.g. passive substitute in Moorthy (1988)). In such settings, firms should not only consider market share loss to their rival, but also the possibility of consumers opting not to buy. While we expect our findings to be less affected qualitatively under SR/SR and N/N equilibria, the quasi-monopoly region under SR/N equilibrium might cease to exist. More detailed analysis of this case is an area for future exploration.

Fourth, we assumed customer preferences are uniformly and independently distributed over the social responsibility and brand dimensions. Consumer preferences for different categories of SR product types may follow different demand distributions, which can also be correlated across brands. Investigating how non-uniform distribution of consumer preferences affects firms strategic decisions are the subject of future research (see, e.g. Neven 1986, and Ansari et al. 1994).

In some competitive situations a firm might decide to follow a market-segmentation strategy by offering both the SR product and the standard counterpart to the marketplace. While the product positioning strategy must deal with possible cannibalization between the two products, the firm might benefit from increased sales

due to spillover effect (see e.g., Chen 2001, and Krishna & Rajan, 2009). Future research could examine whether the equilibria types identified in this study still emerge when firms offer product portfolios. Finally, testing the assumptions and predictions of the proposed model through empirical studies is a subject for future exploration.

Appendix: Proofs of Lemmas and Propositions

A1. Proofs of Pricing Equilibrium Lemmas

A2.1. Proof of lemma 1 (N/N Case):

Let $B_1 = 0$ and $B_2 = 1$ to be the brand locations of firm 1 and 2, respectively. Using standard calculus, for indifferent customer we have: $\theta_{ind}^{B} = \frac{1}{2} + \frac{p_j - p_{-j}}{2t}$.

The demands for firms 1 and 2 are then F(θ_{ind}^{B}), and 1- F(θ_{ind}^{B}), respectively, where F(.) is cumulative distribution function. Assuming that θ_i^B is uniformly distributed over [0, 1], we have $D_j = \frac{1}{2} - \frac{p_j - p_{-j}}{2t}$. The profit for firm j is $\pi_j = D_j(p_j - c_j)$, for j = 1, 2. In the N/N case, the marginal cost of providing non-SR product for both firms is c^N. Using first order conditions for jointly maximizing the profits ($\frac{\partial \pi_j}{\partial p_j} = 0,\ j = 1, 2$), we obtain the symmetric and unique equilibrium prices $p_N^{N/N} = t + c^N$. The second order conditions for maximization are satisfied: $\frac{\partial^2 \pi_j}{\partial {p_j}^2} = \frac{-1}{t} < 0, j = 1, 2$. Consequently, under N/N scenario, firms divide the market equally ($D_N^{N/N} = \frac{1}{2}$), and gain symmetric and unique equilibrium profits $\pi_N^{N/N} = \frac{t}{2}$. *Q.E.D.*

A2.2. Proof of lemma 2 (SR/SR Case):

Using standard calculus, for indifferent customer we get: $\theta_{ind}^{B} = \frac{1}{2} + \frac{p_j - p_{-j}}{2t^{SR}}$. Assuming uniform distribution of θ_i^B for both ordinary and hardcore customers, $D_j = (\frac{1}{2} - \frac{p_j - p_{-j}}{2t^{SR}})(1 + \alpha)$. The profit for firm j is $\pi_j = D_j(p_j - c^{SR})$, for j = 1, 2, where c^{SR} is the marginal cost of providing SR product for both firms. Using first order conditions for

jointly maximizing the profits ($\frac{\partial \pi_j}{\partial p_j} = 0,\ j = 1, 2$), we obtain the symmetric and unique equilibrium prices $p_{SR}^{SR/SR} = t^{SR} + c^{SR}$. The second order conditions for maximization are satisfied: $\frac{\partial^2 \pi_j}{\partial {p_j}^2} = \frac{-(1+\alpha)}{t^{SR}} < 0,\ j = 1, 2$. Consequently, under SR/SR scenario, firms divide the market demand equally, $D_{SR}^{SR/SR} = \frac{1+\alpha}{2}$, and gain symmetric and unique equilibrium profits of $\pi_{SR}^{SR/SR} = \frac{t^{SR}(1+\alpha)}{2}$. *Q.E.D.*

A2.3. Proof of lemma 3 (SR/N Case):

For each type of dominance, there are three types of equilibria:

Type 1: The equilibrium occurs on the strictly convex segment of $D_N^{SR/N}$ and strictly concave segment of $D_{SR}^{SR/N}$ (see Figure 3.b: Lower Triangle).

Type 2: The equilibrium occurs on linear segments of $D_N^{SR/N}$ and $D_{SR}^{SR/N}$ (see Figure 2).

Type 3: The equilibrium occurs on the strictly concave segment of $D_N^{SR/N}$ and strictly convex segment of $D_{SR}^{SR/N}$ (see Figure 3.a: Upper Triangle). We will analyze each type of equilibrium for vertical and horizontal dominance conditions, sequentially.

Vertical Dominance ($t + t^{SR} < 1$)

- **Equilibrium Type 1, denoted as Eq^{V1} (Lower Triangle):**

  This type of equilibrium occurs when the equilibrium prices $p_N^{SR/N}$ and $p_{SR}^{SR/N}$ are relatively high and low, respectively. This is the case when ordinary customers buy standard product only if their ideal brand is very close to the non-SR brand and have low willingness to pay for social attribute (see Figure 3b). It can be readily verified

from the indifferent customer's line equation $\theta_{ind}^{SR} = (t + t^{SR})\theta_{ind}^{B} + p_{SR}^{SR/N} - p_{N}^{SR/N} - t$ and Figure 3.b, that the existence conditions are $p_{SR}^{SR/N} - t \leq p_{N}^{SR/N} \leq p_{SR}^{SR/N} + t^{SR}$. The aggregate demand for the standard products is determined by integrating the $\theta_{ind}^{SR}(\theta_{i}^{B})$ function over $[\frac{t + p_{N}^{SR/N} - p_{SR}^{SR/N}}{t+t^{SR}}, 1]$: $D_{N}^{SR/N} = \frac{(t^{SR} + p_{N}^{SR/N} - p_{SR}^{SR/N})^2}{2(t+t^{SR})}$. The demand for the SR firm then is calculated as the difference between the total market size and the ordinary market segment, i.e. (1 - D_N), plus the hardcore customers' demand (α): $D_{SR}^{SR/N} = \alpha + (1 - D_{N}^{SR/N}) = \alpha + 1 - \frac{(t^{SR} + p_{N}^{SR/N} - p_{SR}^{SR/N})^2}{2(t+t^{SR})}$. Let us define X = $t^{SR} + p_{N}^{SR/N} - p_{SR}^{SR/N}$. The FOCs ($\frac{\partial \pi_j}{\partial p_j} = 0,\ j = 1, 2$) are equivalent to:

$$\frac{\partial \pi_{SR}^{SR/N}}{\partial p_{SR}^{SR/N}} = 0: \quad \alpha + 1 - \frac{X^2}{2(t+t^{SR})} - \frac{(p_{SR}^{SR/N} - c^{SR})X}{t+t^{SR}} = 0, \qquad (1)$$

$$\frac{\partial \pi_{N}^{SR/N}}{\partial p_{N}^{SR/N}} = 0: \quad \frac{X^2}{2(t+t^{SR})} - \frac{(p_{N}^{SR/N} - c^{N})X}{t+t^{SR}} = 0. \qquad (2)$$

For simplicity, we normalize c^N to zero, and c^{SR} to the extra marginal cost of providing SR products versus the non-SR products ($c^{SR} - c^{N}$).

Solving FOCs (1) and (2) for equilibrium prices we get $p_{N}^{SR/N} = \frac{p_{SR}^{SR/N} + t^{SR}}{3}$, and X= $\frac{(t+t^{SR})(\alpha+1)}{p_{N}^{SR/N} + p_{SR}^{SR/N} - c^{SR}}$, that leads to $p_{SR}^{SR/N} = \frac{3(c^{SR} + X^{LT}) - 5t^{SR}}{8}$ and $p_{N}^{SR/N} = \frac{t^{SR} + c^{SR} + X^{LT}}{8}$, where $X^{LT} = \sqrt{(t^{SR} + c^{SR})^2 + 8(\alpha + 1)(t + t^{SR})}$.

The second order conditions for maximization ($\frac{\partial^2 \pi_j}{\partial p_j{}^2} < 0$, j=1,2) are satisfied at equilibrium prices:

$\frac{\partial^2 \pi_{SR}^{SR/N}}{\partial p_{SR}^{SR/N^2}} = \frac{2p_N^{SR/N} - 3p_{SR}^{SR/N} + c^{SR} - 2t^{SR}}{t + t^{SR}} < 0$, as $p_{SR}^{SR/N} \geq c^{SR}$ and based on existence conditions $-1 \leq p_N^{SR/N} - p_{SR}^{SR/N} - t^{SR} \leq 0$.

$\frac{\partial^2 \pi_N^{SR/N}}{\partial p_N^{SR/N^2}} = \frac{3p_N^{SR/N} - 2p_{SR}^{SR/N} - 2t^{SR}}{t + t^{SR}} < 0$, as we have $p_N^{SR/N} = \frac{p_{SR}^{SR/N} + t^{SR}}{3} > 0$ in equilibrium.

Consequently, the unique and asymmetric demands and profits for each firm can be calculated by calculus:

$D_{SR}^{SR/N} = \frac{12(\alpha+1)(t+t^{SR}) - (t^{SR}+c^{SR})^2 - (t^{SR}+c^{SR})X^{LT}}{16(t+t^{SR})}$, and $D_N^{SR/N} = \frac{(t^{SR}+c^{SR}+X^{LT})^2}{32(t+t^{SR})}$

$\pi_{SR}^{SR/N} = \frac{[18(\alpha+1)(t+t^{SR}) + (t^{SR}+c^{SR})^2]X^{LT} + (t^{SR}+c^{SR})^3 - 42(\alpha+1)(t+t^{SR})(t^{SR}+c^{SR})}{16(t+t^{SR})}$, and

$\pi_N^{SR/N} = \frac{(t^{SR}+c^{SR}+X^{LT})^3}{256(t+t^{SR})}$.

Finally, the existence conditions $p_{SR}^{SR/N} - t \leq p_N^{SR/N} \leq p_{SR}^{SR/N} + t^{SR}$ are true iff $0 \leq c^{SR} \leq 2t + t^{SR} - \alpha - 1$. *Q.E.D.*

- **Equilibrium Type 2, denoted as Eq^{V2} (linear demands):**

This type of equilibrium occurs when the equilibrium prices $p_N^{SR/N}$ and $p_{SR}^{SR/N}$ have intermediate values. This equilibrium holds when all ordinary customers with $\theta_i^{SR} = 0$ buy non-SR products and all ordinary customers with $\theta_i^{SR} = 1$ buy SR products. This case corresponds to the case illustrated in Figure 2.a. From the indifferent customer's line equation $\theta_{ind}^{SR} = (t + t^{SR})\theta_{ind}^{B} + p_{SR}^{SR/N} - p_N^{SR/N} - t$ and Figure 2.a, the existence conditions are $p_{SR}^{SR/N} - t \leq p_N^{SR/N} \leq p_{SR}^{SR/N} + t - 1$.

The aggregate demand for the non-SR products, is calculated by integrating the $\theta_{ind}^{SR}(\theta_i^B)$ function over $[0, 1]$: $D_N^{SR/N} = (p_{SR}^{SR/N} - p_N^{SR/N} - \frac{t - t^{SR}}{2})$. The demand for SR

firm can then be calculated as $D_{SR}^{SR/N} = \alpha + \left(1 - D_N^{SR/N}\right) = \alpha + 1 - p_{SR}^{SR/N} + p_N^{SR/N} + \frac{t - t^{SR}}{2}$. The FOCs ($\frac{\partial \pi_j}{\partial p_j} = 0,\ j = 1, 2$) are equivalent to:

$$\alpha + 1 - 2p_{SR}^{SR/N} + p_N^{SR/N} + \frac{t - t^{SR}}{2} + c^{SR} = 0 \text{ , and } p_{SR}^{SR/N} - 2p_N^{SR/N} - \frac{t - t^{SR}}{2} + c^N = 0.$$

The second order conditions for maximization are satisfied: $\frac{\partial^2 \pi_j}{\partial {p_j}^2} = -2 < 0,\ j = 1, 2.$

Using FOCs for jointly maximizing the profits we get unique equilibrium prices $p_{SR}^{SR/N} = \frac{2a + 2c^{SR} + c^N + 2}{3} + \frac{t - t^{SR}}{6}$ and $p_N^{SR/N} = \frac{a + c^{SR} + 2c^N + 1}{3} - \frac{t - t^{SR}}{6}$.

Consequently, the unique and asymmetric demands and profits for each firm can be calculated using standard calculus:

$D_{SR}^{SR/N} = \frac{2(a+1) - (c^{SR} - c^N)}{3} + \frac{t - t^{SR}}{6}$, and $D_N^{SR/N} = \frac{(a+1) + (c^{SR} - c^N)}{3} - \frac{t - t^{SR}}{6}$

$\pi_{SR}^{SR/N} = \frac{1}{9}\left[2(a+1) + \frac{t - t^{SR}}{2} - (c^{SR} - c^N)\right]^2$, and $\pi_{SR}^{SR/N} = \frac{1}{9}\left[(a+1) - \frac{t - t^{SR}}{2} + (c^{SR} - c^N)\right]^2$. Setting $c^N = 0$ we get the results provided in table 3.

Finally, the existence conditions $p_{SR}^{SR/N} - t \le p_N^{SR/N} \le p_{SR}^{SR/N} + t - 1$ are true iff $2t + t^{SR} - \alpha - 1 \le c^{SR} \le 2 - t - 2t^{SR} - \alpha$. *Q.E.D.*

- **Equilibrium Type 3, denoted as Eq^{V3} (Upper Triangle):**

This type of equilibrium occurs when the equilibrium prices $p_N^{SR/N}$ and $p_{SR}^{SR/N}$ are relatively low and high, respectively. This is the case when ordinary customers buy from SR firm only if they highly prefer the SR brand and have high willingness to pay for social attribute. This case corresponds to graph (a) in Figure 3.

It can be readily verified from the indifferent customer's line equation $\theta_{ind}^{SR} = (t + t^{SR})\theta_{ind}^B + p_{SR}^{SR/N} - p_N^{SR/N} - t$ and Figure 3.a, that the existence conditions

are $p_{SR}^{SR/N} - t - 1 \leq p_N^{SR/N} \leq p_{SR}^{SR/N} + t^{SR} - 1$. The aggregate demand for the SR firm, can be calculated as $D_{SR}^{SR/N} = \alpha + \int_{\theta^B=0}^{\theta^B=(1+t-p_{SR}^{SR/N}+p_N^{SR/N})/((t+t^{SR})} 1\text{-}[(t + t^{SR})\theta_{ind}^B + p_{SR}^{SR/N} - p_N^{SR/N} - t\,]\, d\theta^B$. Using calculus we get $D_{SR}^{SR/N} = \alpha + \frac{(1+t-p_{SR}^{SR/N}+p_N^{SR/N})^2}{2(t+t^{SR})}$. The demand for SR firm can then be calculated as $D_N^{SR/N} = 1 - (D_{SR}^{SR/N} - \alpha) = 1 - \frac{(1+t-p_{SR}^{SR/N}+p_N^{SR/N})^2}{2(t+t^{SR})}$. Let us define Y = $1 + t - p_{SR}^{SR/N} + p_N^{SR/N}$. The FOCs ($\frac{\partial \pi_j}{\partial p_j} = 0,\ j = 1, 2$) are equivalent to:

$$\frac{\partial\, \pi_{SR}^{SR/N}}{\partial\, p_{SR}^{SR/N}} = 0: \ \ \alpha + \frac{Y^2}{2(t+t^{SR})} - \frac{(p_{SR}^{SR/N} - c^{SR})\mathrm{Y}}{t+t^S} = 0, \qquad (3)$$

$$\frac{\partial\, \pi_N^{SR/N}}{\partial\, p_N^{SR/N}} = 0: \ \ 1 - \frac{Y^2}{2(t+t^{SR})} - \frac{(p_N^{SR/N} - c^N)\mathrm{Y}}{t+t^{SR}} = 0. \qquad (4)$$

For simplicity, we normalize c^N to zero, and c^{SR} to the extra marginal cost of providing SR products compared to the non-SR products ($c^{SR} - c^N$).

Solving FOCs (3) and (4) for equilibrium prices we get Y= $\frac{(t+t^{SR})(\alpha+3)}{4p_N^{SR/N}+t+1-c^{SR}}$, and $p_{SR}^{SR/N} = p_N^{SR/N} + t + 1 - \frac{(t+t^{SR})(\alpha+3)}{4p_N^{SR/N}+t+1-c^{SR}}$. Solving the quadratic equation (4) using Y= $\frac{(t+t^{SR})(\alpha+3)}{4p_N^{SR/N}+t+1-c^{SR}}$ leads to unique equilibrium price for non-SR products$p_N^{SR/N} = \frac{X^{UT1} - (5-\alpha)(t+1-c^{SR})}{8(1-\alpha)}$, where $X^{UT1} = \sqrt{(t+1-c^{SR})^2(5-\alpha)^2 + 8(1-\alpha)[(\alpha+3)^2(t+t^{SR}) - 2(t+1-c^{SR})^2]}$

The equilibrium price for SR products can then be calculated as

$p_{SR}^{SR/N} = \frac{(7-3\alpha)c^{SR} + (1-5\alpha)(t+1) + X^{UT2}}{8(1-\alpha)}$, where $X^{UT2} = \sqrt{[(7-3\alpha)c^{SR} + (1-5\alpha)(t+1)]^2 + 8(1-\alpha)[(3\alpha+1)^2(t+t^{SR}) - 6(c^{SR})^2 + 2\alpha(t+1)^2 + (6\alpha-2)(t+1)c^{SR}]}$

The second order conditions for maximization ($\frac{\partial^2 \pi_j}{\partial {p_j}^2} < 0$, j=1, 2) at equilibrium prices are as follows:

$\frac{\partial^2 \pi_N^{SR/N}}{\partial {p_N^{SR/N}}^2} = \frac{2(p_{SR}^{SR/N} - t - 1) - 3p_N^{SR/N}}{t + t^{SR}} < 0$ is satisfied, as based on existence conditions $p_N^{SR/N} \geq p_{SR}^{SR/N} - t - 1$.

$\frac{\partial^2 \pi_{SR}^{SR/N}}{\partial {p_{SR}^{SR/N}}^2} = \frac{3p_{SR}^{SR/N} - 2(p_N^{SR/N} + t + 1) - c^{SR}}{t + t^{SR}}$ can be either positive or negative. The aforementioned pricing equations are for the interior solution where $p_{SR}^{SR/N} < \frac{2(p_N^{SR/N} + t + 1) + c^{SR}}{3}$, such that the S.O.C. is satisfied. Otherwise, we will have the corner solution where the SR firm loses the entire ordinary consumer market segment to the N firm and exclusively serves the hardcore segment.

Consequently, the unique and asymmetric demands and profits for each firm can be calculated using calculus:

$D_{SR}^{SR/N} = \frac{32\alpha(t + t^{SR}) + [t + 1 - c^{SR} + X^{UT1} - X^{UT2}]^2}{32(t + t^{SR})}$, and

$D_N^{SR/N} = \frac{32(t + t^{SR}) - [t + 1 - c^{SR} + X^{UT1} - X^{UT2}]^2}{32(t + t^{SR})}$

$\pi_{SR}^{SR/N} = \frac{[X^{UT2} + (t + 1 - c^{SR})(1 - 5\alpha)][32\alpha(t + t^{SR}) + [t + 1 - c^{SR} + X^{UT1} - X^{UT2}]^2]}{256(t + t^{SR})(1 - \alpha)}$, and

$\pi_N^{SR/N} = \frac{[X^{UT1} - (t + 1 - c^{SR})(5 - \alpha)][32(t + t^{SR}) - [t + 1 - c^{SR} + X^{UT1} - X^{UT2}]^2]}{256(t + t^{SR})(1 - \alpha)}$.

Finally, the existence conditions $p_{SR}^{SR/N} - t - 1 \leq p_N^{SR/N} \leq p_{SR}^{SR/N} + t^{SR} - 1$ are true iff $c^{SR} \geq 2 - t - 2t^{SR} - \alpha$. *Q.E.D.*

Horizontal Dominance ($t + t^{SR} > 1$)

- **Equilibrium Type 1, denoted as Eq^{H1} (Lower Triangle):**

Equilibrium configurations are the same as Eq^{V1}, and the existence conditions are true iff $0 \leq c^{SR} \leq 2 - t - 2t^{SR} - \alpha(t + t^{SR})$.

- **Equilibrium Type 2, denoted as Eq^{H2} (linear demands):**

This type of equilibrium is similar to the Eq^{V2} and occurs when the equilibrium prices $p_N^{SR/N}$ and $p_{SR}^{SR/N}$ are at intermediate levels. This holds when all ordinary customers with $\theta_i^B = 0$ buy non-SR products and all ordinary customers with $\theta_i^B = 1$ buy SR products, as illustrated in Figure 2.b. From the indifferent customer's line equation $\theta_{ind}^{SR} = (t + t^S)\theta_{ind}^B + p_{SR}^{SR/N} - p_N^{SR/N} - t$ and Figure 2.b, that the existence conditions are $p_{SR}^{SR/N} - t \leq p_N^{SR/N} \leq p_{SR}^{SR/N} + t - 1$.

The aggregate demand for the non-SR products, is determined by integrating the $\theta_{ind}^B(\theta_{ind}^{SR})$ function over [0, 1]: $D_N^{SR/N} = (\frac{2t^{SR} + 2p_{SR}^{SR/N} - 2p_N^{SR/N} - 1}{2(t + t^{SR})})$. The demand for SR firm can then be calculated as $D_{SR}^{SR/N} = \alpha + \left(1 - D_N^{SR/N}\right) = \alpha + \frac{2t - 2p_{SR}^{SR/N} + 2p_N^{SR/N} + 1}{2(t + t^{SR})}$.

The FOCs ($\frac{\partial \pi_j}{\partial p_j} = 0,\ j = 1, 2$) are equivalent to:

$\alpha(t + t^{SR}) + t - 2p_{SR}^{SR/N} + p_N^{SR/N} + c^{SR} + \frac{1}{2} = 0$, and $t^{SR} + p_{SR}^{SR/N} - 2p_N^{SR/N} + c^N - \frac{1}{2} = 0$.

The second order conditions for maximization are satisfied: $\frac{\partial^2 \pi_j}{\partial {p_j}^2} = \frac{-2}{t + t^{SR}} < 0,\ j = 1, 2$. Using FOCs for jointly maximizing the profits, the unique equilibrium prices are $p_{SR}^{SR/N} = \frac{2[a(t + t^{SR}) + t + c^{SR}] + t^{SR} + c^N}{3} + \frac{1}{6}$, and $p_N^{SR/N} = \frac{a(t + t^{SR}) + t + c^{SR} + 2(t^{SR} + c^N)}{3} - \frac{1}{6}$.

Consequently, the unique and asymmetric demands and profits for each firm can be calculated using calculus:

$D_{SR}^{SR/N} = \frac{2a}{3} + \frac{4t+2[t^{SR}-(c^{SR}-c^{N})]+1}{6(t+t^{SR})}$, and $D_{N}^{SR/N} = \frac{a}{3} + \frac{4t^{SR}+2[t+(c^{SR}-c^{N})]-1}{6(t+t^{SR})}$

$\pi_{SR}^{SR/N} = \frac{[2a(t+t^{SR})+2t+t^{SR}-(c^{SR}-c^{N})+\frac{1}{2}]^{2}}{9(t+t^{SR})}$, and $\pi_{N}^{SR/N} = \frac{[a(t+t^{SR})+t+2t^{SR}+(c^{SR}-c^{N})-\frac{1}{2}]^{2}}{9(t+t^{SR})}$.

Setting $c^{N} = 0$ we get the results provided in table 3. Furthermore, the existence conditions $p_{SR}^{SR/N} - t \leq p_{N}^{SR/N} \leq p_{SR}^{SR/N} + t - 1$ are true iff $2 - t - 2t^{SR} - \alpha(t + t^{SR}) \leq c^{SR} \leq 2t + t^{SR} - \alpha(t + t^{SR}) - 1$. *Q.E.D.*

- **Equilibrium Type 3, denoted as Eq^{H3} (Upper Triangle):**

Equilibrium configurations are the same as Eq^{V3}, and the existence conditions are true iff $c^{SR} \geq 2t + t^{SR} - \alpha(t + t^{SR}) - 1$.

A2.Proofs of Product Equilibrium Propositions

A2.1. Proof of Propositions 1, 2 and 3:

We prove the general case of Proposition 3, where $\alpha \geq 0$ *and* $c^{SR} \geq c^{N} = 0$, and the proofs of Proposition 1 and Proposition 2 follow by setting $c^{SR} \geq c^{N} = 0$ and $\alpha = 0$, respectively. Let $\Delta Lead(\alpha, c^{SR}, t, t^{SR}) = \pi_{SR}^{SR/N} - \pi_{N}^{N/N}$ and $\Delta Follow(\alpha, c^{SR}, t, t^{SR}) = \pi_{SR}^{SR/SR} - \pi_{N}^{SR/N}$ to be the firms' *Lead* and *Follow* incentives,[9] as discussed in Proposition 3. The expressions $\pi_{N}^{N/N}$, $\pi_{SR}^{SR/SR}$, $\pi_{SR}^{SR/N}$, and $\pi_{N}^{SR/N}$ are presented in Lemmas 1-3. Note that both $\Delta Lead(\alpha, c^{SR}, t, t^{SR})$ and $\Delta Follow(\alpha, c^{SR}, t, t^{SR})$ are piecewise and continuous functions, as $\pi^{N/N}$, $\pi^{SR/SR}$, $\pi_{SR}^{SR/N}$, and $\pi_{N}^{SR/N}$ are all continuous functions over

[9] The notation is adapted from Geng and Shulman (2015).

their domains. When both incentives are positive (negative) both firms develop SR (non-SR) products. When only $\Delta Lead(\alpha, c^{SR}, t, t^{SR})$ is positive, one of the firms develops SR products while the other firm develops non-SR products. Thus, we are interested in the sign of $\Delta Lead$ and $\Delta Lead$ for different parameters values.

First, we identify the parameters values, where $\Delta Lead = 0$. $\alpha = f_{Lead}(c^{SR}, t, t^{SR})$ is derived by solving the $\Delta Lead = 0$ with respect to α. Below, we show steps for deriving the $\alpha = f_{Lead}(c^{SR}, t, t^{SR})$ function for the linear demand case under Vertical Dominance. $\alpha = f_{Lead}(c^{SR}, t, t^{SR})$ for other cases is determined using similar steps and omitted[10]. From the expressions in Lemma 1 and Lemma 3 we have:

$$\Delta Lead(\alpha, c^{SR}, t, t^{SR}) = \pi_{SR}^{SR/N} - \pi_{N}^{N/N} = \frac{1}{9}\left[2(\alpha+1) + \frac{t - t^{SR}}{2} - c^{SR}\right]^2 - \frac{t}{2}$$

Set $\Delta Lead(\alpha, c^{SR}, t, t^{SR}) = 0$: $2(\alpha+1) + \frac{t-t^{SR}}{2} - c^{SR} - 3\sqrt{\frac{t}{2}} = 0$

Solve the above equation with respect to α:[11]

$$\alpha = f_{Lead}(c^{SR}, t, t^{SR}) = \frac{2c^{SR} + 3\sqrt{2t} - t + t^{SR}}{4} - 1$$

[10] $\alpha = f_{Lead}(c^{SR}, t, t^{SR})$ is a piecewise function, as $\Delta Lead$ is a continuous and piecewise function. The domain for each piece is the same as the existence conditions of π_{SR} in Lemma 3. Here, we only provide derivation steps of the linear demands piece of $\alpha = f_{Lead}(c^{SR}, t, t^{SR})$ under Vertical Dominance condition. Calculation of pieces associated with the Upper and Lower Triangle cases follows similar steps and is omitted.

[11] Following similar steps for linear demands case under Horizontal Dominance condition:

$$\alpha = f_{Lead}(c^{SR}, t, t^{SR}) = \frac{3\sqrt{2t(t + t^{SR})} - 4t - 2t^{SR} + 2c^{SR} - 1}{4(t + t^{SR})}$$

Next, we analyze $\alpha = f_{Lead}(c^{SR}, t, t^{SR})$ as a function of c^{SR}. We define $0 < c^{SR} = \overline{c}(t, t^{SR})$ such that $\alpha = f_{Lead}|_{c^{SR}=\overline{c}(t,t^{SR})} = 0$. Solving $\alpha = f_{Lead} = 0$ with respect to c^{SR} for the linear demand case under Vertical Dominance: $\overline{c}(t, t^{SR}) = 2 + \frac{t - t^{SR} - 3\sqrt{2t}}{2}$.

$\alpha = f_{Lead}(c^{SR}, t, t^{SR})$ curve reflects parameters values such that $\Delta Lead = 0$. Since $\alpha = f_{Lead}|_{c^{SR}=\overline{c}(t,t^{SR})} = 0$, and $f_{Lead}(c^{SR}, t, t^{SR})$ is continuous and increasing in c^{SR}, it is straight forward to show that $\Delta Lead$ is positive for any c^{SR} less than $\overline{c}(t, t^{SR})$. For any point of (c^{SR}, α), where $c^{SR} \geq \overline{c}(t, t^{SR})$ and $0 \leq \alpha < 1$, we have $\Delta Lead > 0$ if $\alpha > f_{Lead}(c^{SR}, t, t^{SR})$ and $\Delta Lead < 0$ if $\alpha < f_{Lead}(c^{SR}, t, t^{SR})$. Please see Figure 4 for illustration ($\Delta Lead < 0$ in region 1, and $\Delta Lead > 0$ in regions 2 and 3).

Next we identify parameters values, where $\Delta Follow = 0$. $\alpha = f_{Follow}(c^{SR}, t, t^{SR})$ is determined by solving the $\Delta Follow = 0$ with respect to α. Below are the derivation steps for $\alpha = f_{Lead}(c^{SR}, t, t^{SR})$ for the linear demand case under vertical dominance. Derivation steps of $\alpha = f_{Lead}(c^{SR}, t, t^{SR})$ for other cases is analogous and omitted[12]. From the expressions in Lemma 2 and Lemma 3 we have:

$$\Delta Follow(\alpha, c^{SR}, t, t^{SR}) = \pi_{SR}^{SR/SR} - \pi_N^{SR/N} = \frac{t^{SR}(1+\alpha)}{2} - \frac{1}{9}\left[(a+1) - \frac{t - t^{SR}}{2} + c^{SR}\right]^2$$

Set $\Delta Follow(\alpha, c^{SR}, t, t^{SR}) = 0$:

[12] $\alpha = f_{Follow}(c^{SR}, t, t^{SR})$ is a piecewise function, as $\Delta Follow$ is a continuous and piecewise function. The domain for each piece is the same as the existence conditions of π_N in Lemma 3. Here we only provide derivation steps of the linear demands piece of $\alpha = f_{Follow}(c^{SR}, t, t^{SR})$ under Vertical Dominance condition. Following similar steps for linear demands case under Horizontal Dominance condition:

$$\alpha = f_{Follow}(c^{SR}, t, t^{SR}) = \frac{2 + t^{SR} - 4t - 4c^{SR} + 3\sqrt{t^{SR}(t^{SR} - 8c^{SR} + 4)}}{4(t + t^{SR})}$$

For the Lower Triangle case: $\alpha = f_{Follow}(c^{SR}, t, t^{SR}) = \frac{(7t^{SR} - c^{SR})\sqrt{2t^{SR}(t^{SR} - c^{SR})} + 10t^{SR^2} - 6t^{SR}c^{SR}}{t + t^{SR}} - 1$

$$\frac{9t^{SR}(1+\alpha)}{2} - [(a+1)^2 - (a+1)(t - t^{SR} - 2c^{SR} + (c^{SR} - \frac{t-t^{SR}}{2})^2]$$

$$= (a+1)^2 + (a+1)\left(2c^{SR} - \frac{7t^{SR}}{2} - t\right) + (c^{SR} - \frac{t-t^{SR}}{2})^2 = 0$$

By solving the above quadratic equation we get:[13]

$$\alpha = f_{Follow}(c^{SR}, t, t^{SR}) = \frac{t}{2} + \frac{7t^{SR}}{4} - c^{SR} + \frac{3}{2}\sqrt{t^{SR}\left(t + \frac{5t^{SR}}{4} - 2c^{SR}\right)} - 1$$

Note that $f_{Follow}(c^{SR}, t, t^{SR})$ is decreasing in c^{SR}, i.e. $\frac{\partial f_{Follow}(c^{SR},t,t^{SR})}{\partial c^{SR}} < 0$, and is at maximum value when $c^{SR} = 0$.[14] We denote $\overline{\alpha}(t, t^{SR}) = Max\ (0, f_{Follow}|_{c^{SR}=0})$. Thus, given $c^N = c^{SR} = 0$, we get $\Delta Follow > 0$ when $\alpha < \bar{\alpha}(t, t^{SR})$. Similarly $\Delta Follow < 0$ when $\alpha > \bar{\alpha}(t, t^{SR})$ and $c^N = c^{SR} = 0$. **This proves Proposition 1.** [15]

Finally, we analyze $\alpha = f_{Follow}(c^{SR}, t, t^{SR})$ as a function of c^{SR}. $f_{Follow}(c^{SR}, t, t^{SR})$ is continuous and decreasing in c^{SR}. Thus, if $\overline{\alpha}(t, t^{SR}) > 0$ (i.e. $f_{Follow}|_{c^{SR}=0} > 0$), there exists $0 < c^{SR} = \underline{c}(t, t^{SR})$ such that $f_{Follow}|_{c^{SR}=\underline{c}(t,t^{SR})} = 0$. Solving $\alpha = f_{Follow} = 0$ with respect to c^{SR} for the linear demand case under Vertical Dominance condition:

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[13] The other root, that is $\alpha = f_{Follow}(c^{SR}, t, t^{SR}) = \frac{t}{2} + \frac{7t^{SR}}{4} - c^{SR} - \frac{3}{2}\sqrt{t^{SR}\left(t + \frac{5t^{SR}}{4} - 2c^{SR}\right)} - 1$ leads to negative values of α, and thus should be ruled out.

[14] $f_{Follow}|_{c^{SR}=0} < 0$ when t^{SR} is very low (precisely when $\frac{t}{2} + \frac{7t^{SR}}{4} + \frac{3}{2}\sqrt{t^{SR}\left(t + \frac{5t^{SR}}{4}\right)} < 1$). Consequently $\Delta Follow < 0$ for the entire feasible region; thus, there will be no SR/SR equilibrium.

[15] As proved earlier, $\Delta Lead(\alpha, c^{SR}, t, t^{SR}) > 0$ at $c^{SR} = c^N = 0 \leq \overline{c}(t, t^{SR})$. Thus, the N/N equilibrium does not occur at $c^{SR} = c^N = 0$.

$$f_{Follow}\left(\underline{c}(t,t^{SR}),t,t^{SR}\right)=\frac{t}{2}+\frac{7t^{SR}}{4}-\underline{c}(t,t^{SR})+\frac{3}{2}\sqrt{t^{SR}\left(t+\frac{5t^{SR}}{4}-2\underline{c}(t,t^{SR})\right)}-1=0$$

$$=>\underline{c}(t,t^{SR})^2+\underline{c}(t,t^{SR})(2-t+t^{SR})+\frac{t^2+{t^{SR}}^2-14t^{SR}-2tt^{SR}}{4}-t+1=0$$

By solving the above quadratic equation we get:[16]

$$\underline{c}(t,t^{SR})=\frac{t-t^{SR}-2+3\sqrt{2t^{SR}}}{2}$$

$\alpha=f_{Follow}(c^{SR},t,t^{SR})$ curve reflects parameters values such that $\Delta Follow=0$. Since $\alpha=f_{Follow}|_{c^{SR}=\underline{c}(t,t^{SR})}=0$, and $f_{Follow}(c^{SR},t,t^{SR})$ is continuous and decreasing in c^{SR}, it is straight forward to show that $\Delta Follow$ is negative for any c^{SR} greater than $\underline{c}(t,t^{SR})$. For any point of (c^{SR},α), where $c^{SR}\leq\underline{c}(t,t^{SR})$ and $0\leq\alpha<1$, we have $\Delta Follow>0$ if $\alpha<f_{Follow}(c^{SR},t,t^{SR})$ and $\Delta Follow<0$ if $\alpha>f_{Follow}(c^{SR},t,t^{SR})$ – see Figure 4 in the main text for illustration ($\Delta Follow<0$ in regions 1 and 2, and $\Delta Follow>0$ in region 3).

Combined results of analysis for $\Delta Lead$ and $\Delta Follow$ functions proves Proposition 3, and propositions 1 and 2 as special cases. The only other condition that needs to always hold is $\underline{c}(t,t^{SR})\leq\overline{c}(t,t^{SR})$.From above expressions for $\underline{c}(t,t^{SR})$ and $\overline{c}(t,t^{SR})$, note that $\overline{c}(t,t^{SR})-\underline{c}(t,t^{SR})=3-3(\sqrt{2t}+\sqrt{2t^{SR}})$ and is decreasing in t^{SR} and *t*. Since under Vertical Dominance condition $t+t^{SR}<1$, $\overline{c}(t,t^{SR})-\underline{c}(t,t^{SR})$ will

[16] The other root, that is $\underline{c}(t,t^{SR})=\frac{t-t^{SR}-2-3\sqrt{2t^{SR}}}{2}$ leads to negative values of c^{SR}, and thus should be ruled out.

be minimized at $t = t^{SR} = \frac{1}{2}$. Thus for $t = t^{SR} = \frac{1}{2}$, $\overline{c}(t, t^{SR}) = \underline{c}(t, t^{SR})$ and for other values of t and t^{SR} we have $\underline{c}(t, t^{SR}) \leq \overline{c}(t, t^{SR})$. **This proves Propositions 2 and 3.** *Q.E.D.*

A2.2. Proof of Proposition 4:

We first consider SR/SR equilibrium where both firms offer SR products. We compare firms' profit in this equilibrium ($\pi_{SR}^{SR/SR}$) to their benchmark profits in N/N equilibrium ($\pi_N^{N/N}$). From expressions in Lemmas 1 and 2 we have $\pi_{SR}^{SR/SR} - \pi_N^{N/N} = \frac{t^{SR}(1+\alpha)}{2} - \frac{t}{2}$. Therefore, when $t < t^{SR}$ we have $\pi_{SR}^{SR/SR} > \pi_N^{N/N}$. When $t > t^{SR}$, $\pi_{SR}^{SR/SR} > \pi_N^{N/N}$ only if $\alpha > \frac{t - t^{SR}}{t^{SR}}$. This proves cases (iv), (v), and SR/SR part of case (i) in Proposition 4.

Next we consider the SR/N equilibrium where one firm offers SR product and the other firm offers non-SR product. From proof of Proposition 3, it is clear that the SR firm always benefits from the asymmetric product positioning strategy, as $\Delta Lead = \pi_{SR}^{SR/N} - \pi_N^{N/N} > 0$. So we only need to compare the benchmark profit ($\pi_N^{N/N}$) to the non-SR firm's profit ($\pi_N^{SR/N}$).

Below, we analyze the linear demand case under the vertical dominance condition. Analysis of other cases is analogous and omitted. We define $g(\alpha, c^{SR}, t, t^{SR}) = \pi_N^{SR/N} - \pi^{N/N}$ and from expressions in Lemmas 1 and 3 we have $g(\alpha, c^{SR}, t, t^{SR}) = \frac{1}{9}(\alpha + 1 - \frac{t - t^{SR}}{2} + c^{SR})^2 - \frac{t}{2}$. To analyze, we drive the parameter values for which $g(\alpha, c^{SR}, t, t^{SR}) = 0$. We drive $\alpha = f_g(c^{SR}, t, t^{SR})$ by solving $g(\alpha, c^{SR}, t, t^{SR}) = 0$ with

respect to α. By simple algebra we get $\alpha = f_g(c^{SR}, t, t^{SR}) = \frac{3\sqrt{2t}+t-t^{SR}-2-c^{SR}}{2}$. Next we analyze $\alpha = f_g(c^{SR}, t, t^{SR})$ as a function of c^{SR}. We define $0 < c^{SR} = c_g(t, t^{SR})$ such that $\alpha = f_g|_{c^{SR}=c_g(t,t^{SR})} = 0$. Solving $\alpha = f_g = 0$ with respect to c^{SR} for the linear demands case under Vertical Dominance condition we get: $c_g(t, t^{SR}) = \frac{3\sqrt{2t}+t-t^{SR}-2}{2}$. Note that $g(\alpha, c^{SR}, t, t^{SR})$ is positive for any c^{SR} greater than $c_g(t, t^{SR})$. For any point of (c^{SR}, α), where $c^{SR} \leq c_g(t, t^{SR})$ and $0 \leq \alpha < 1$, we have $g(\alpha, c^{SR}, t, t^{SR}) < 0$ if $\alpha < f_g(c^{SR}, t, t^{SR})$ and $g(\alpha, c^{SR}, t, t^{SR}) > 0$ if $\alpha > f_g(c^{SR}, t, t^{SR})$. Please see Figure 5.b in for illustration.

Finally, given $t < t^{SR}$, we prove that if $g(\alpha, c^{SR}, t, t^{SR}) < 0$ then $\Delta Follow > 0$. That is, when $t < t^{SR}$, $g(\alpha, c^{SR}, t, t^{SR})$ is positive in the SR/N region; thus, firm N benefits from the asymmetric product positioning strategy. To prove, note that when $t < t^{SR}$, we have $c_g(t, t^{SR}) < \underline{c}(t, t^{SR})$. Also note that while both f_g and f_{Follow} are decreasing in c^{SR}, f_{Follow} decreases at a higher rate ($\frac{\partial f_{Follow}(c^{SR},t,t^{SR})}{\partial c^{SR}} < \frac{\partial f_g(c^{SR},t,t^{SR})}{\partial c^{SR}} < 0$). That means when $t < t^{SR}$, for any $c^{SR} \leq c_g(t, t^{SR})$, we have $f_{Follow} > f_g$. Therefore, when $t < t^{SR}$, for any point of (c^{SR}, α), where $c^{SR} \leq c_g(t, t^{SR})$ and $0 \leq \alpha < 1$, if $\alpha < f_g(c^{SR}, t, t^{SR})$ then $\alpha < f_{Follow}(c^{SR}, t, t^{SR})$. That means, when $t < t^{SR}$, $\pi_N^{SR/N} < \pi_N^{N/N}$ implies $\Delta Follow > 0$. This proves cases (ii), (iii), and SR/N part of case (i) in Proposition 4. *Q.E.D.*

A3. Proof of Lemma 4:

For each potential type of market equilibrium identified in Lemma 3, let CU^O and CU^H be the overall utility of consumers in ordinary and hardcore market segments,

respectively. Total Consumers' utility under each market equilibrium is denoted as CU^T and can then be calculated as $CU^T = CU^O + CU^H$. We will analyze N/N, SR/SR and each type of SR/N equilibrium for vertical and horizontal dominance conditions, sequentially.

1- N/N Equilibrium:

Note that the consumers in hardcore segment do not buy under this equilibrium condition. As such, $CU^H = 0$ and $CU^T = CU^O$. From ordinary consumer's utility function, and the firms' demand and prices identified in proof of Lemma 1:

$$CU^O = \int_{\theta^{SR}=0}^{\theta^{SR}=1} \int_{\theta^B=0}^{\theta^B=0.5} v^o - p_N^{N/N} - t(\theta^B - 0)\, d\theta^B\, d\theta^{SR}$$

$$+ \int_{\theta^{SR}=0}^{\theta^{SR}=1} \int_{\theta^B=0.5}^{\theta^B=1} v^o - p_N^{N/N} - t(1 - \theta^B)\, d\theta^B\, d\theta^{SR}$$

$$= 2 \int_{\theta^{SR}=0}^{\theta^{SR}=1} \frac{1}{2}(v^o - p_N^{N/N} - \frac{t}{4})\, d\theta^{SR} = v^o - p_N^{N/N} - \frac{t}{4} = v^o - 1.25t$$

2- SR/SR Equilibrium:

From hardcore and ordinary consumers' utility functions, and the firms' demand and prices identified in proof of Lemma 2:

$$CU^O = \int_{\theta^B=0}^{\theta^B=0.5} \int_{\theta^{SR}=0}^{\theta^{SR}=1} v^o + \theta^{SR} - p_{SR}^{SR/SR} - t^{SR}(\theta^B - 0)\, d\theta^{SR}\, d\theta^B$$

$$+ \int_{\theta^B=0.5}^{\theta^B=1} \int_{\theta^{SR}=0}^{\theta^{SR}=1} v^o + \theta^{SR} - p_{SR}^{SR/SR} - t^{SR}(1 - \theta^B)\, d\theta^{SR}\, d\theta^B$$

$$= \frac{1}{2}(v^o + 0.5 - p_{SR}^{SR/SR} - \frac{t^{SR}}{4}) + \frac{1}{2}(v^o + 0.5 - p_{SR}^{SR/SR} - \frac{t^{SR}}{4})$$

$$= v^o + 0.5 - p_{SR}^{SR/SR} - \frac{t^{SR}}{4} = v^o + 0.5 - c^{SR} - 1.25\, t^{SR}$$

$$CU^H = \alpha \int_{\theta^B=0}^{\theta^B=0.5} \int_{\theta^{SR}=0}^{\theta^{SR}=1} v^H + \theta^{SR} - p_{SR}^{SR/SR} - t^{SR}(\theta^B - 0)\, d\theta^{SR}\, d\theta^B$$

$$+ \alpha \int_{\theta^B=0.5}^{\theta^B=1} \int_{\theta^{SR}=0}^{\theta^{SR}=1} v^H + \theta^{SR} - p_{SR}^{SR/SR} - t^{SR}(1 - \theta^B)\, d\theta^{SR}\, d\theta^B$$

$$= \alpha(v^H + 0.5 - p_{SR}^{SR/SR} - \frac{t^{SR}}{4}) = \alpha(v^H + 0.5 - c^{SR} - 1.25\, t^{SR})$$

3- SR/N Equilibrium:

We analyze different types of SR/N equilibrium under vertical and horizontal dominance conditions, sequentially. From hardcore and ordinary consumers' utility functions, and the firms' demand and prices identified in proof of Lemma 3, for Vertical Dominance condition ($t + t^{SR} < 1$):

- **Equilibrium Type 1, denoted as Eq^{V1} (Lower Triangle):**

For simplicity, let $b = p_{SR}^{SR/N} - p_N^{SR/N} - t$, where $p_{SR}^{SR/N}$ and $p_N^{SR/N}$ are firms' prices associated to this equilibrium, and are identified in proof of Lemma 3:

$$CU^O = \int_{\theta^{SR}=0}^{\theta^{SR}=1} \int_{\theta^B=0}^{\theta^B=-\frac{b}{t+t^{SR}}} v^o + \theta^{SR} - p_{SR}^{SR/N} - t^{SR}(\theta^B - 0)\, d\theta^B\, d\theta^{SR}$$

$$+ \int_{\theta^B=-\frac{b}{t+t^{SR}}}^{\theta^B=1} \int_{\theta^{SR}=(t+t^{SR})\theta^B+b}^{\theta^{SR}=1} v^o + \theta^{SR} - p_{SR}^{SR/N} - t^{SR}(\theta^B - 0)\, d\theta^{SR}\, d\theta^B$$

$$+ \int_{\theta^B=-\frac{b}{t+t^{SR}}}^{\theta^B=1} \int_{\theta^{SR}=0}^{\theta^{SR}=(t+t^{SR})\theta^B+b} v^o - p_N^{SR/N} - t(1 - \theta^B)\, d\theta^{SR}\, d\theta^B$$

The first to expressions capture the overall utility of ordinary consumers who buy SR products, and the last expression captures the overall utility of ordinary consumers who buy non-SR products. Using standard calculus:

$$CU^O = v^O - p_{SR}^{SR/N} + 0.5 * (1 - t^{SR} + \frac{b^3}{3(t+t^{SR})} + b(t+t^{SR}) + b^2 + \frac{(t+t^{SR})^2}{3})$$

For overall utility of consumers in the hardcore market segment we have:

$$CU^H = \alpha \int_{\theta^B=0}^{\theta^B=1} \int_{\theta^{SR}=0}^{\theta^{SR}=1} v^H + \theta^{SR} - p_{SR}^{SR/N} - t^{SR}(\theta^B - 0)\, d\theta^{SR}\, d\theta^B$$

$$= \alpha(v^H + 0.5 - p_{SR}^{SR/N} - 0.25\, t^{SR})$$

- **Equilibrium Type 2, denoted as Eq^{V2} (linear demands):**

For simplicity let $b = p_{SR}^{SR/N} - p_N^{SR/N} - t$, where $p_{SR}^{SR/N}$ and $p_N^{SR/N}$ are firms' prices associated to this equilibrium, and identified in proof of Lemma 3:

$$CU^O = \int_{\theta^B=0}^{\theta^B=1} \int_{\theta^{SR}=(t+t^{SR})\theta^B+b}^{\theta^{SR}=1} v^o + \theta^{SR} - p_{SR}^{SR/N} - t^{SR}(\theta^B - 0)\, d\theta^{SR}\, d\theta^B$$

$$+ \int_{\theta^B=0}^{\theta^B=1} \int_{\theta^{SR}=0}^{\theta^{SR}=(t+t^{SR})\theta^B+b} v^o - p_N^{SR/N} - t(1 - \theta^B)\, d\theta^{SR}\, d\theta^B$$

The first to expression captures the overall utility of ordinary consumers who buy SR products, and the second expression captures the overall utility of ordinary consumers who buy non-SR products. Using standard calculus:

$$CU^O = v^O - p_{SR}^{SR/N} + 0.5 * (1 - t^{SR} + b^2 + b(t+t^{SR}) + \frac{(t+t^{SR})^2}{3})$$

The overall utility of consumers in the hardcore segment will be similar to the prior case and we have: $CU^H = \alpha(v^H + 0.5 - p_{SR}^{SR/N} - 0.25\, t^{SR})$.

- **Equilibrium Type 3, denoted as Eq^{V3} (Upper Triangle):**

For simplicity, let $b = p_{SR}^{SR/N} - p_N^{SR/N} - t$, where $p_{SR}^{SR/N}$ and $p_N^{SR/N}$ are firms' prices associated to this equilibrium, and are identified in proof of Lemma 3:

$$CU^O = \int_{\theta^{SR}=0}^{\theta^{SR}=1} \int_{\theta^B=\frac{1-b}{t+t^{SR}}}^{\theta^B=1} v^o - p_N^{SR/N} - t(1-\theta^B)\, d\theta^B\, d\theta^{SR}$$

$$+ \int_{\theta^B=0}^{\theta^B=\frac{1-b}{t+t^{SR}}} \int_{\theta^{SR}=0}^{\theta^{SR}=(t+t^{SR})\theta^B+b} v^o - p_N^{SR/N} - t(1-\theta^B)\, d\theta^{SR}\, d\theta^B$$

$$+ \int_{\theta^B=0}^{\theta^B=\frac{1-b}{t+t^{SR}}} \int_{\theta^{SR}=(t+t^{SR})\theta^B+b}^{\theta^{SR}=1} v^o + \theta^{SR} - p_{SR}^{SR/N} - t^{SR}(\theta^B - 0)\, d\theta^{SR}\, d\theta^B$$

The first two expressions capture the overall utility of ordinary consumers who buy non-SR products, and the last expression captures the overall utility of ordinary consumers who buy SR products. Using standard calculus: $CU^O = v^O - p_N^{SR/N} - \frac{t}{2} + \frac{(1-b)^3}{6(t+t^{SR})}$, and the overall utility of consumers in the hardcore segment will be similar to the prior case where: $CU^H = \alpha(v^H + 0.5 - p_{SR}^{SR/N} - 0.25\, t^{SR})$.

Next we analyze different types of SR/N equilibrium under horizontal dominance condition ($t + t^{SR} > 1$). The equilibrium configurations for Upper and Lower Triangle cases are the same as those in vertical dominance condition. For the linear demand case under horizontal dominance condition we have:

- **Equilibrium Type 2, denoted as Eq^{H2} (linear demands):**

For simplicity, let $b = p_{SR}^{SR/N} - p_N^{SR/N} - t$, where $p_{SR}^{SR/N}$ and $p_N^{SR/N}$ are firms' prices associated to this equilibrium, and are identified in proof of Lemma 3:

$$CU^O = \int_{\theta^{SR}=0}^{\theta^{SR}=1} \int_{\theta^B=0}^{\theta^B=\frac{\theta^{SR}-b}{t+t^{SR}}} v^o + \theta^{SR} - p_{SR}^{SR/N} - t^{SR}(\theta^B - 0)\, d\theta^B\, d\theta^{SR}$$

$$+ \int_{\theta^{SR}=0}^{\theta^{SR}=1} \int_{\theta^B=\frac{\theta^{SR}-b}{t+t^{SR}}}^{\theta^B=1} v^o - p_N^{SR/N} - t(1-\theta^B)\, d\theta^B\, d\theta^{SR}$$

The first two expression captures the overall utility of ordinary consumers who buy SR products, and the second expression captures the overall utility of ordinary consumers who buy non-SR products. Using standard calculus: $CU^O = v^O - p_N^{SR/N} - \frac{t}{2} + \frac{b^2-b+1/3}{2(t+t^{SR})}$. The overall utility of consumers in the hardcore segment will be similar to the prior case, where: $CU^H = \alpha(v^H + 0.5 - p_{SR}^{SR/N} - 0.25\, t^{SR})$. *Q.E.D.*

A4. Proof of Proposition 5:

All cases in Proposition 5 are replications of Propositions 3 and 4 for the innovator-follower setting with one exception: For the SR/SR scenario in Proposition 5, case (i), i.e. when $\Delta Lead > 0$ and $\Delta Follow > 0$, if $\alpha < \frac{t-t^{SR}}{t^{SR}}$, none of the firms offer the SR product. This is due to the innovator realizing that offering the SR product will trigger the follower to do the same, as $\Delta Lead > 0$ and $\Delta Follow > 0$. As shown earlier in Proposition 4, $\alpha < \frac{t-t^{SR}}{t^{SR}}$ implies $\pi_{SR}^{SR/SR} < \pi_N^{N/N}$. Therefore, the innovator does not

lead SR product development in an effort to avoid anticipated profit loss from a possible match of strategy by the follower. *Q.E.D.*

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