

The Role of Brand Image and Product Characteristics on Firms' Entry and OEM Decisions*

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How Brand Image and Product Characteristics can Govern firms' OEM and Entry Decisions

Abstract

This paper shows that differences in brand image and product quality (horizontal and vertical differentiation) can govern the market-entry decisions of firms facing a market already served by an incumbent. The entrant might sell under its own brand, become a supplier to the incumbent (called an OEM arrangement), or both.

Findings reveal that when firms are vertically but not horizontally differentiated, the entrant cannot profit from entering the market on its own, but firms can profit from OEM arrangements. When firms are both vertically and horizontally differentiated, the entrant profits by simultaneously entering the market and establishing an OEM arrangement with the incumbent. This is an interesting outcome because in competitive scenarios in which firms compete for consumers, the entrant will effectively sell its own product to the competitor. Furthermore, in those competitive scenarios, both buyer and seller increase profits by agreeing on a high wholesale price.

When firms have the capability of producing all possible qualities of the products on their own, OEM relationships between firms can still happen in equilibrium. In this case, the most interesting result is the fact that, under certain conditions, firms may select to produce goods of different qualities and become suppliers to each other, despite the fact that they will end up selling the same product qualities to consumers. The reason for this outcome is that this dual buyer-seller arrangement causes a strategic effect that reduces the firms' aggressiveness when competing for consumers.

Key Words: Channel Cooperation, Competitive Strategy, Game Theory, Industrial Marketing, Market Entry, Price Discrimination.

1 Introduction

In the modern business environment, it is common practice to establish *original equipment manufacturer* (OEM) agreements between firms: agreements in which one firm produces and sells goods to another firm, to be resold to end consumers under the latter's brand. For example, consider the electronics industry. Many powerful contract manufacturers such as Celestica, Flextronics, and Sanmina serve as OEM suppliers to well-known firms such as Apple, Dell, HP, and Microsoft.

While the contract manufacturers above have demonstrated little to no initiative in selling directly to end consumers, other firms in the electronics industry possess product development and marketing capabilities that allow them to sell to consumers under their own brands. For instance, the company HTC, not only supplies phones to other companies, but also sells them to consumers (Yoffie and Kim 2009). Even traditional name brand companies supply products to other firms in OEM arrangements. Examples include: Pentax selling its digital single-lens reflex cameras to Samsung, which resold them under its own brand (Richards 2006); Canon selling wide-format printers to end consumers and also to Océ, which rebadges the products and resells them to business customers (Printing World 2006); and EMC selling enterprise storage systems directly to customers and to HP (Zhu 2000).

The above examples refer to companies in the electronics industry. However, the phenomenon of a company deciding to take the role of the manufacturer in an OEM arrangement or to take the role of a branding company by selling to consumers is not exclusive to that sphere. The same phenomenon is documented in other industries.¹

When reflecting on the examples above, one realizes the importance of understanding the optimal entry and OEM decisions of a firm, which possesses branding and marketing capabilities and has the opportunity to sell products to consumers under its own brand or through an OEM arrangement. This rises several research questions: (1) When would it be better for the entrant to enter the market on its own? (2) When would it be better to act as an OEM supplier? (3) When would it be better to pursue both OEM and entry simultaneously? (4) Would it be possible for the firms to become OEM suppliers to each other? Furthermore, when firms seek an OEM arrangement: (5) What is the optimal wholesale price? (6) Would the firms' incentives regarding the wholesale price be aligned (win-win situation) or unaligned (the gains of a firm come at the expense of the other firm)?

To address these questions, we develop a game-theory model that considers a potential entrant facing a market that an incumbent already serves.² The model examines the entrant's outcomes with respect to four strategic choices: stay out of the market; sell to the incumbent in an OEM arrangement; compete with the incumbent by selling to end consumers; or adopt a two-pronged approach by selling both to the incumbent and to end consumers. Different consumers' preferences,

¹For instance, Braiconf SA, an Eastern-European clothing manufacturer sells under its own portfolio of brands and has OEM arrangements with other brands in Western Europe (Yoruk 2002). Another example is the case of Suzuki (a brand associated with compact Japanese vehicles) entering the U.S. market with the Swift and also selling the car to GM (a brand associated with large American cars) which resold it as the GEO Metro (Consumer Guide 1995).

²The type of entrant we are considering has the capabilities to compete on par with established incumbents. Thus, we do not approach these questions with a perspective based on barriers of entry that prevent companies from competing in the market. Instead, we aim to close a gap in the literature by focusing on rationales that are based on strategic effects that stem from consumers' heterogenous preferences for brand images and product characteristics.

brand images, and product characteristics are considered, giving rise to different combinations of horizontal and vertical differentiation scenarios, and creating price-discrimination opportunities.

The model analysis identifies the conditions that make a particular entry and/or OEM strategy dominate the others. It also identifies when the self-interested entrant and incumbent are likely to take adversarial or cooperative standpoints regarding wholesale price negotiations. More specifically, results show that if consumers do not perceive a significant difference between the incumbent's and the entrant's brand images (firms are not horizontally differentiated), the entrant stays out of the market and establishes an OEM arrangement with the incumbent. The reason is that this strategy not only avoids a negative effect on prices that would emerge if firms in the market end up competing for the same consumers (the *demand-competition* effect), but also activates a positive effect on pricing that occurs when goods of varying qualities in the market allow firms to extract a higher surplus from consumers (the *surplus-extraction* effect).

If consumers perceive a moderate difference between the incumbent's and the entrant's product images (products are horizontally differentiated), then the entrant enters the market and sells its product to end consumers using its own brand, and also establishes an OEM arrangement with the incumbent. In this particular situation, an interesting phenomenon occurs: not only the entrant (the seller) but also the incumbent (the buyer) benefits by contracting on high wholesale prices. This result in which the entrant sells its product to end consumers and to the incumbent (thus creating extra competition) is shaped not only by the demand-competition, and surplus-extraction effects, but also by a *price-increasing* effect, in which high wholesale prices for the OEM product (the product manufactured by the entrant and resold to consumers by the incumbent) drive up the consumer prices for all products in the market and increase firms' revenues. The net result is that the combination of the surplus-extraction and price-increasing effects overpowers the demand-competition effect.

When consumers perceive such a great difference between the firms' brand images that firms act as local monopolies, then the entrant enters the market and OEMs the product to the incumbent. In this case, the main forces are the surplus-extraction effect, and the added effect that OEM becomes a means for the entrant to sell to an otherwise unreachable market (the *market-access* effect).

An extension to the model that allows firms to endogenously select the quality of their products shows that, while there are situations in which the most production-efficient firm will supply the products, there are other situations in which firms will decide to differentiate in goods production and become suppliers to each other. In this particular scenario an interesting outcome emerges: although firms optimally choose to differentiate in terms of production strategy, they follow the same vertically-undifferentiated marketing strategy of selling products with the same qualities to end consumers.

The paper proceeds as follows: In the remainder of this section, we position the paper with respect to the existing literature. Section 2 presents the model. Section 3 studies scenarios in which there is no horizontal differentiation, while Section 4 studies scenarios in which products are horizontally differentiated. Section 5 extends the analysis by considering exogenous production choices and multi-product manufacturing. The paper concludes in Section 6 by summarizing the results, presenting managerial implications, and discussing research limitations and possible future extensions.

1.1 Literature review

The literature in pure market entry is well-established. Seminal work by (Bain 1956) on entry barriers found that a firm should enter a market if the *investment at entry* is less than the value of *expected post-entry profits*. While the literature recognizes that many factors can influence these two major components (Gatignon, Weitz, and Bansal 1990; Green, Barclay, and Ryans 1995), the major focus of systematic investigation has been related to costs, such as scale economies, sunk costs, limit pricing, absolute cost advantages (opportunity costs, rents, experience-related costs, network economies, etc.), product differentiation (cost to mimic an established incumbent, such as design, advertising, and marketing), and switching costs (Gilbert 1989). More recently, the literature started to investigate firms' strategic behavior as an element influencing entry decisions (Berry and Reiss 2007); however, no research explores OEM contracting as an entry-mode choice in the way ours does.

The literature on firms' decisions to engage in OEM relationships is more scarce and also tends to focus on cost elements (Frazier, Spekman, and O'Neal 1988; Buvik and John 2000; Cannon and Homburg 2001). The bulk of this literature takes a supply-chain perspective and considers buyer-seller relationships of goods that go into the final products (the good is a component of the product sold to end consumers). Almost no research focuses on OEM arrangements involving final products.

The modeling underpinnings of this research relate to the price-discrimination literature. Early papers (see Varian 1989 for a review) focused on how a firm can vary its prices across consumers to extract more surplus from them. Subsequent research studied price discrimination aided by additional marketing tools, such as coupons (Narasimhan 1984), and the role of addressability and targetability in price-discrimination outcomes (Chen and Iyer 2002; Chen, Narasimhan, and Zhang 2001; Shaffer and Zhang 1995, 2002). Further research examined situations in which firms initially lack information on consumer preferences, but can learn those preferences from past consumer behavior (Koenigsberg, Muller, and Vilcassim 2008; Villas-Boas 1999), or could use timing as a price discrimination tool (Che, Narasimhan, and Padmanabhan 2010).

This research is also closely related to the work of Liu and Zhang (2006). They focus on the decisions of a retailer who can acquire information about consumers and target promotions accordingly (conduct first-degree price discrimination) so as to discourage a partner manufacturer from implementing a direct-selling channel. The current manuscript provides a different contribution because here both firms have the ability to market their own product without the aid of the other firm, here the focus is on optimal entry and OEM decisions (as opposed to entry-deterrence decisions), and also here firms do not know the exact preferences of each consumer. Hence, firms cannot implement personalized promotions; they can at most implement a *price-and-quality* mechanism (second-degree price discrimination) that induces groups of consumers to choose different offerings.

The focus of this paper is on interactions between manufacturers; however, this research has connections with the literature in dual channels. Some of the main topics covered in this literature are the trade-offs between channel integration and decentralization (Trivedi 1998), channel coordination (Chiang, Chhajed, and Hess 2003), and implications for pricing strategies (Lee and Staelin 1997; Cai 2010). With the emergence of electronic commerce, other papers investigated whether a firm

should establish a direct channel, and the implications of channel conflict and market competition on the optimal channel structure (Bernstein, Song, and Zheng 2008; Choi 2003; Kumar and Ruan 2006) and on the provision of other marketing mix elements such as price, service, and channel incentives (Rubel and Zaccour 2007; Tsay and Agrawal 2004; Zhang 2009). Besides the difference in the substantive focus, this manuscript exhibits other key differences with respect to the established dual-channel models: (a) here the incumbent is able to produce and sell a product on its own; hence, it is different from a typical retailer; (b) in the OEM arrangement, the product produced by the entrant and sold by the incumbent inherits the brand image of the incumbent; and (c) the simultaneous heterogeneity in firms' characteristics and consumer preferences allows different horizontal and vertical differentiation cases and for second-degree price discrimination. To our knowledge, such a problem (with all combinations of heterogeneous firms and consumers) has not been explored in the literature, and thus, our research provides novel insights on this specific dual-channels issue.

The paper is also related to the literature on narrow versus wide distribution. In a model that considers both direct and retailing outlets, Balasubramanian (1998) shows that high market coverage, due to intense direct-marketing efforts, may result in depressed profits. Liu, Putler, and Weinberg (2004) study a model of commercial television broadcast (which was further refined by Liu et al. 2006 and by Chou and Wu 2006). They find that, under certain conditions, more channels may have a negative effect on both product quality and profitability. Godes, Ofek, and Sarvary (2009) investigate a two-sided platform in which firms can sell both media content and advertising. Among their findings, they discover that firms may benefit from intense substitution if one of the firms possesses a captive market. These papers provide important contributions to the literature, but they do not speak to the issue of a firm deciding to supply the product to another firm and/or enter the market and compete with another firm. In this substream of research, the paper more related to our model is that of Arya, Mittendorf, and Sappington (2005). They study the situation in which a manufacturer may encroach on its retailer's operations by selling the product directly to final consumers. They find that the encroached-on producer may implement relatively lower wholesale prices. This result contrasts with the findings in our paper mainly because, in their model, firms compete for a single segment of consumers, and thus lower wholesale prices can be beneficial to the supplier because they reduce double marginalization. Conversely, in our model, firms compete for more than one segment of consumers, and thus firms may prefer to implement high wholesale prices to reduce price competition across all segments.

There also exists literature on licensing between competing firms that relates to our research. Some of these papers focus on antitrust implications and suggest policy recommendations to prevent collusion and increase welfare (Shapiro 1985; Lin 1996; Fauli-Oller and Sandonís 2002). Taking the perspective of the firm, Katz and Shapiro (1985) investigated fixed-fee licensing of cost-reducing technological advances by Cournot competitors, and concluded that major advances will not be licensed. Subsequent research investigated the possibility of both a fixed-fee and a royalty (per-unit) fee in oligopolistic Cournot and Bertrand competitive markets (Rockett 1990; Kamien, Oren, and Tauman 1992; Wang 1998 and 2002). These papers identified conditions under which firms may prefer a fixed-fee or a royalty contract. A more recent paper by Li and Yanagawa (2011) considers

a Stackelberg manufacturer that can offer two-part tariff licensing and compares the results with those of the previous research. The substantive focus of the research on licensing differs from that in our research. Furthermore, none of these papers investigate how the existence of multiple consumer segments may dictate firms incentives to enter a market and/or OEM their products to competitors, or consider the possibility of reciprocal supply arrangements as we do.

2 Model setup

Consider a two-stage game with two firms, an incumbent and an entrant, indexed by $k \in \{i, e\}$, where i identifies the incumbent and e identifies the entrant.³ In the first stage, the entrant chooses whether or not to enter the market (sell its product to end consumers under the entrant’s brand) and whether or not to establish an OEM arrangement with the incumbent (sell its product to the incumbent, so that the incumbent can resell it to the end consumers using the incumbent’s brand). In the second stage, firms set prices for end consumers. This type of scenario speaks to the go-to-market decisions of a firm facing a new market, and also the go-to-market decisions of a firm considering to extend its brand into a new category.

We assume that one of the firms is able to produce a low-quality product with marginal cost $c_{kL} = 0$ and the other a high-quality product with marginal cost $c_{kH} > 0$ (with $c_{iH} \neq c_{eH}$). We use the index $q \in \{L, H\}$ to reference quality. Being able to produce the product does not mean that the firm is required to produce it; hence, a firm may decide not to produce a product if it is not profitable to do so. When products are offered to consumers, firms charge a price p_k .

If the incumbent and the entrant establish an OEM arrangement, the wholesale price is w , determined by a take-it-or-leave-it offer by one of the firms. This is equivalent to saying that one of the firms is a Stackelberg *Leader* with respect to the wholesale price and the other is the Stackelberg *Follower* (the analysis will consider both cases). As will be seen later, the fact that OEM contracts are based on the more conventional wholesale price only (instead of another more complex contract such as two-part tariff) does not influence the firms’ strategic decisions, thus it is not a major limitation of the model. We discuss this issue in more detail in §6. We further assume that either entering the market or establishing an OEM contract requires an infinitesimally small cost, so that the entrant will pursue a strategy only if it yields an improvement in profit outcomes.

We consider that products in the market may be both vertically and horizontally differentiated (see Desai 2001 and Kim, Shi, and Srinivasan 2001 for similar models of vertical and horizontal differentiation). Vertical differentiation arises from objective differences in product quality and differences in consumers’ heterogenous valuation of product quality. For simplicity, it is assumed that there are two types of consumers represented by a taste for quality parameter θ , which can be either $\bar{\theta}$ (*choosy* consumers who have high valuation for quality) or $\underline{\theta}$ (*cheap* consumers who have low valuation for quality). The probability of a consumer being type $\bar{\theta}$ is $Prob(\bar{\theta}) = \lambda_{\bar{\theta}} = \lambda$ with $\lambda \in (0, 1)$ and the probability of a consumer being type $\underline{\theta}$ is $Prob(\underline{\theta}) = \lambda_{\underline{\theta}} = 1 - \lambda$. It is assumed that firms know the

³For expositional purposes, we will use the index $-k$ to indicate the “other firm”. Indexes will be dropped when the meaning is directly inferred from the text.

proportion λ (and consequently $1 - \lambda$), but that the type of a consumer is private information, i.e., firms cannot observe whether a consumer is cheap or choosy.

We define $V(\theta, q)$ to be a function that captures the value a consumer of type θ derives from consuming the product of quality q as follows: $V(\theta, L) = \theta v$, and $V(\theta, H) = \theta(v + \Delta)$, where v is the baseline value of the product, $\Delta > c_{kH}$ (so that the differential value provided by a high-quality product compensates the higher cost of producing it) captures the extra value provided by a high quality product, and $\theta \in \{\bar{\theta}, \underline{\theta}\}$ with $\bar{\theta} > \underline{\theta} = 1$ not only captures a consumer type, but also acts as a parameter that expresses the magnitude of the difference in valuations between consumer segments. We remark that the qualitative results would be unchanged if cheap consumers had no valuation for quality differences and only valued the basic level of the product v . We assume that the value function parameters (θ , v , and Δ) are such that firms always find it better to serve both segments of consumers.

To capture horizontal differentiation, we consider that consumers in the market perceive not only differences in product qualities, but also differences in the firms' brand images (that reflect on product image).⁴ For instance, one can think of a market in which consumers have different tastes with regard to the country of origin of automobiles (domestic versus imported) and two companies (a domestic and a foreign automaker) sell cars of different performances or luxury appointments. One can also think of a market in which consumers have idiosyncratic tastes for technical versus fashion clothing and two firms (one with a reputation for technical apparel, the other for design) sell jackets of different qualities. We assume that each consumer has an ideal preference point reflecting her image preferences. These ideal points are uniformly distributed on a Hotelling linear-city market with size one. The consumer whose ideal product image is located at x and who consumes a product from a firm located at x^0 derives utility $u = V(\cdot) - p - t|x^0 - x|$, where t is a "transportation cost" parameter, which in this paper represents the magnitude of the disutility from purchasing a product that does not match her brand image preference. This means that products with the same objective vertical quality can be seen differently by consumers depending on which firm is branding the product. From a substantive marketing perspective, this captures real-world situations such as when a name brand company markets a product that was designed and manufactured by another company (for instance, when Océ markets a printer designed and manufactured by Canon).

We assume that firms are located at the extreme points of the Hotelling line (without loss of generality, the incumbent at point $x = 0$, and the entrant at point $x = 1$). In this setup, firms are horizontally undifferentiated when $t = 0$, (meaning that consumers face no disutility from buying any brand) and horizontally differentiated when $t > 0$ meaning that consumers experience a positive disutility from buying a product that does not match their brand preferences). This is a well-known method of capturing differentiation (Tirole 1988, p. 280) and was successfully employed by previous research in marketing (see, for instance, Chen and Iyer 2002). In the analysis we will explore different horizontal differentiation scenarios that may occur given the magnitude of the parameter t .

⁴As in Tremblay and Polasky (2002), we assume that firms have a brand image that reflects on the image of the products sold by the firm. Hence, we use brand image and product image interchangeably. We notice that other firm characteristics, such as location, clientele, service and targeting approach may have the same qualitative meaning as brand image differentiation (see, for instance, Dukes, Gal-Or, and Srinivasan 2006).

Throughout the paper, we assume that brand images are exogenous to the model. Exogeneity of brand image captures real-world situations in which the entrant cannot quickly or easily alter its brand perceptions, or situations in which a brand has an inherent characteristic (such as country of origin or brand associations created by an intensive advertising campaign) that is impractical to change, or that is not worth changing given the entire product portfolio under the firm's brand.

Regarding product qualities, in the first part of the analysis, we assume that product qualities are exogenous as well. This captures real-world situations in which the entrant has limited capacity to adjust product quality (such as when firms have limited access to components), situations in which the R&D process is long (and thus, quality decisions have to be made well in advance), and situations in which products need to comply with a number of product standards. In the second part of the analysis, we extend the model by allowing firms to choose product qualities endogenously.

The timing of the game is as follows: In the first stage, the entrant decides its own action (no entry, OEM only, entry only, OEM and entry). In the interim, if the entrant seeks an OEM arrangement, the wholesale price (w) is decided by a take-it-or-leave-it offer from the Leader to the Follower. In the second stage, each firm sets the prices of its product to consumers (p_i and, if entry occurs, p_e), and demand is realized (consumers buy the products as a function of the final prices).

The game is solved by applying the principle of sequential rationality (Mas-Colell, Whinston, and Green 1995, p. 267-305), and finding the subgame perfect Nash equilibrium: First we determine the optimal consumer prices in the second stage, by taking as given the entry decisions (and wholesale price, if OEM is contracted) from the previous stages. Next, for the situations in which firms can reach an OEM agreement, we determine the optimal wholesale price (interim stage), according to a Stackelberg process. Lastly, we determine the optimal entrant's decision in the first stage, by taking into account anticipated profits for each possible decision.

3 Firms are vertically differentiated only

As a baseline, we first consider situations in which consumers do not see significant differences between brand images ($t = 0$). The only possibility of differentiation is the quality of the products. Examples could include products that are valued by functionality or quality characteristics, such as computer memory (which could have more or less access speed), power tools (consumer versus professional grade), and energy generators (with different energy efficiencies).

Before discussing the outcomes in this scenario, we establish and discuss two facts:

First, because $t = 0$, regardless of consumer location, utility from firm k is $u_{\theta k} = V(\theta, q_k) - p$. Thus, if firm k provides more utility for a consumer of type θ than firm $-k$ does, then all consumers of the same type (same segment) should prefer firm k 's product. Hence, when $u_{\theta k} > u_{\theta -k}$, firm k 's demand from a given type θ of consumers is $d_{\theta k} = \{\lambda_{\theta} \text{ if } u_{\theta k} \geq 0, 0 \text{ otherwise}\}$, while demand for firm $-k$ is $d_{\theta -k} = 0$. If $u_{\theta k} = u_{\theta -k}$ then, by assumption, firms split the demand.

Second, because one consumer segment values quality more than the other, a firm that has only one product will not be able to recoup the full value of the product. However, if a firm has two products, it can extract more value from consumers through price discrimination: charging a (higher)

price \bar{p} for a high-quality product and a (lower) price \underline{p} for a low-quality product,⁵ the following *Incentive Compatibility* conditions (also known as *Separation* conditions) should be observed:

$$V(\bar{\theta}, H) - \bar{p} \geq V(\bar{\theta}, L) - \underline{p} \implies \bar{\theta}(v + \Delta) - \bar{p} \geq \bar{\theta}v - \underline{p}, \text{ and } V(\underline{\theta}, H) - \bar{p} \leq V(\underline{\theta}, L) - \underline{p} \implies v + \Delta - \bar{p} \leq v - \underline{p}.$$

These conditions can be simplified as:

$$[IC_{\bar{\theta}k}]: \bar{p} \leq \underline{p} + \bar{\theta}\Delta, \quad [IC_{\underline{\theta}k}]: \bar{p} \geq \underline{p} + \Delta.$$

These facts are important for the following reasons. The absence of horizontal differentiation means that small price or quality differences allow a firm to capture the entirety of a segment of consumers. Thus, if the entrant were to enter the market and compete with the incumbent, the intensity of competition would be severe. The reason is that, within a segment, once a firm undercuts the other, it captures the entire segment. A countervailing force is the existence of two segments of consumers, which soften the degree of competition between firms. Since firms produce different product-qualities, they have asymmetric views on the profitability of targeting each segment of consumers. Furthermore, the two segments make it valuable for a firm to have two products, because they enable the firm to extract more surplus from consumers.

With these determinations we are able to discuss the equilibrium outcomes in this scenario (derivations are in Appendix A).

Since firms are vertically differentiated, one may expect that the entrant could enter the market and earn positive profit. However, if the entrant were to enter the market without an OEM arrangement, competition for consumers would be fierce. Thus, the overall outcome for the firms, which we denote as π_k^{*E} , is depressed by the demand competition effect.

On the other hand, if the entrant were to stay out of the market and supply the OEM product to the incumbent, the latter would be able to extract maximum surplus from consumers by directing the low-quality product to cheap consumers and charging the price $\underline{p}_i = v$ (a price equal to the value of the product), and the high-quality product to choosy consumers and charging the price $\bar{p}_i = v + \bar{\theta}\Delta$ (the maximum price that still implements price-discrimination). The outcome for the firms conditional on the wholesale price w , which we denote as $\pi_k^O|w$, would be such that $\pi_i^O|w + \pi_e^O|w > \pi_i^{*E} + \pi_e^{*E}$ for all real values of w ; therefore, there are wholesale prices that make it better for both firms to engage in an OEM arrangement.

Furthermore, Appendix A also shows that the incumbent and the entrant have unaligned incentives with respect to the wholesale price: the incumbent's profit decreases with the wholesale price, while the entrant's profit increases. This means that if the incumbent is the Leader, it will offer to the entrant a wholesale price w^* such that it extracts all the rent from the entrant. More precisely, the incumbent will offer a wholesale price such that the entrant ends up with an OEM outcome that is barely above the entry outcome ($\pi_e^O|w^* = \pi_e^{*E}$). The entrant accepts the offer, since it is no worse than entering the market on its own. Conversely, when the entrant is the Leader, it offers to sell the OEM product at a high price, that makes the incumbent barely indifferent about purchasing the product or facing the competitive outcome ($\pi_i^O|w^* = \pi_i^{*E}$).

Lastly, neither entry in conjunction with OEM, nor the incumbent dropping its own product and

⁵Truought this paper when a company sells two different products with two different prices we use \bar{p} to denote the price of the high-quality product and \underline{p} to denote the price of the low-quality product.

selling the entrant's product are good strategies for the firms, because either approach triggers an intense undifferentiated Bertrand competitive outcome in at least one of the segments.

The discussion above leads to the following proposition:

Proposition 1 *When brands are undifferentiated, the entrant stays out of the market and supplies its product to the incumbent. In this configuration, firms have unaligned incentives with respect to the wholesale price: if the incumbent (entrant) is the Leader, it extracts all of the extra surplus by buying (selling) the OEM product at a low (high) wholesale price.*

Proof. In Appendix A. ■

The rationale behind Proposition 1 is that when products are differentiated only vertically, the differentiation between the firms' products makes it possible for the entrant to enter the market and earn positive profit. However, entry by the entrant would trigger intense competition between the two firms (the demand-competition effect would be intense). This would cause profits to drop and consequently, firms' profitability to suffer. On the other hand, when an OEM arrangement is reached and the entrant stays out of the market, not only is competition non-existent (nullifying the demand-competition effect), but also the incumbent becomes able to price-discriminate consumers (activating the surplus-extraction effect). Therefore, the aggregate profit outcome is higher when firms engage in an OEM arrangement than when they compete for consumers.

All of this benefit, though, is not shared equally by the firms. The Leader can make a take-it-or-leave-it offer that extracts all of the extra rents from the Follower through the wholesale price w . Outcomes for the incumbent decrease with w , while outcomes for the entrant increase. Therefore, if the incumbent is the Leader, the threat of intense competitive reaction that would ensue if the entrant were to enter the market forces the entrant to accept selling the OEM product at a low price. Conversely, if the entrant is the Leader, the credible threat of entering the market and competing fiercely for consumers forces the incumbent to accept paying a high price for the OEM product.

In conclusion, even if products are differentiated and entering the market would yield positive profit for the entrant, the firm does better by staying out of the market and becoming an OEM supplier to the incumbent. In this case, the OEM arrangement does not have the function of providing to the entrant access to other markets or customers. Instead, it is an instrument that reduces potential market competition. This outcome is very beneficial to the Leader in the vertical relationship, who is able to extract all of the extra surplus through the proper pricing of the OEM product.

An apt example is the case of Motorola's decision with respect to the WLAN networking market. Although Motorola has a well-known brand, it decided to participate in this market by becoming an OEM supplier to other companies, such as Extreme Network (Korzeniowski 2009).

4 The impact of horizontal differentiation

In this section, we explore how adding a degree of horizontal differentiation changes the competitive landscape and impacts firms equilibrium strategies. Technically, we operationalize this type of situ-

ation by considering that consumers experience a positive disutility from buying a brand that does not match their ideal preference points (recall the examples provided in §2).

As in Desai (2001), we consider that firms are sufficiently differentiated so that there is a pure strategy equilibrium in the pricing subgame. We focus on two equilibrium configuration scenarios that can emerge depending on the magnitude of the transportation cost t with respect to the value and marginal costs of the products: neither segment is fully served by the two firms (defined as local monopolistic or incomplete market coverage), and both segments can be fully served by the two firms (defined as competitive or full market coverage).⁶ Below we investigate both scenarios (derivations are in Appendix B).

Firms are local monopolists (incomplete market coverage)

When the transportation cost t is very large, firms do not compete for each other's consumers. Firm's demands are obtained by finding, for each segment, the consumer who is indifferent about buying the product or not. In other words, the consumer such that $u_{q_k} = 0$.

If no OEM arrangement is established, firms target the two segments with a single product. In this case, the profit function for the firms is: $\pi_k = (p_k - c_k) \left(\lambda \frac{V(\bar{\theta}, q_k) - p_k}{t} + (1 - \lambda) \frac{V(\underline{\theta}, q_k) - p_k}{t} \right)$. By solving for the optimal prices, we obtain the optimal profit outcome for the firms: $\pi_k^{*E} = \frac{[(1-\lambda)V(\underline{\theta}, q_k) + \lambda V(\bar{\theta}, q_k) - c_k]^2}{4t}$. This expression confirms that profit outcomes for the firms are independent of each other (as one would expect). We also notice that because $\pi_k^{*E} > 0$ for both firms, the entrant always finds it better to enter the market than to stay out of the market.

Appendix B shows that if the entrant enters the market and also OEMs the product to the incumbent, there are values for the wholesale price w such that profit outcomes with OEM-and-entry, denoted as $\pi_k^{EO}|w$, are higher than those achieved with entry only for both firms ($\pi_k^{EO}|w \geq \pi_k^{*E}$); thus, entry in conjunction with OEM is Pareto improving and dominates entry only.

The appendix also shows that the incumbent desires the lowest possible wholesale price, therefore we conclude that when the incumbent is the Leader, it will offer to buy the OEM product at the minimum wholesale price w so that the entrant still prefers to OEM the product over going into the market alone (technically, the incumbent offers to buy the product for a wholesale price $w^* = w_i^{indif}$ such that $\pi_e^{EO}|w_i^{indif} = \pi_e^{*E}$).

The situation for the entrant is slightly different. Although the entrant desires high prices, it faces the standard double marginalization problem; thus, the entrant may select to implement an "interior" wholesale price w_e^{FOC} that is not bounded by the *gains from trade* constraint that $\pi_i^{EO}|w_e^{indif} = \pi_i^{*E}$ (technically, the entrant Leader offers to sell the OEM product at a price $w^* = \min\{w_e^{FOC}, w_e^{indif}\}$).

Firms can compete for consumers (full market coverage)

When the transportation cost t is not too large, firms can compete for each other's consumers. If

⁶The regularity conditions for the first scenario (incomplete market coverage) requires t to be very large ($t = \lfloor \frac{V(\bar{\theta}, q_i) + V(\bar{\theta}, q_e) - c_i - c_e}{3} \rfloor$), while the regularity conditions for the second scenario (full market coverage) requires t to be not too large ($t \in \llbracket \lfloor \frac{V(\underline{\theta}, q_i) - V(\underline{\theta}, q_e) - c_i + c_e}{3} \rfloor, \lfloor \frac{V(\underline{\theta}, q_i) + V(\underline{\theta}, q_e) - c_i - c_e}{3} \rfloor \rrbracket$).

firms go to market independently, firms' demands are obtained by finding, for each segment, the consumer who is indifferent about buying from either firm: the marginal consumer located at x_θ^* such that, $V(\theta, q_k) - p_k - tx_\theta = V(\theta, q_k) - p_{-k} - t(1 - x_\theta)$. In this case, the profit function for the firms is: $\pi_k = (p_k - c_k) \left[\lambda \left(\frac{1}{2} + \frac{(V(\bar{\theta}, q_k) - V(\bar{\theta}, q_{-k})) - (p_k - p_{-k})}{2t} \right) + (1 - \lambda) \left(\frac{1}{2} + \frac{(V(\underline{\theta}, q_k) - V(\underline{\theta}, q_{-k})) - (p_k - p_{-k})}{2t} \right) \right]$.

This expression is true, provided the following *Differentiated Demand* condition is satisfied for both choosy and cheap consumers:⁷

$$[DD_\theta] : (V(\theta, q_i) - p_i) + (V(\theta, q_e) - p_e) > t.$$

If the entrant were to enter the market and compete with the incumbent, one solves for the optimal prices and finds that optimal profit outcomes for the firms of

$$\pi_k^{*E} = \frac{\{3t - c_k + c_{-k} + \lambda[V(\bar{\theta}, q_k) - V(\bar{\theta}, q_{-k})] + (1 - \lambda)[V(\underline{\theta}, q_k) - V(\underline{\theta}, q_{-k})]\}^2}{18t}.$$

Since $\pi_k^{*E} > 0$ for both firms, it is evident that, for the entrant, entering the market is always better than staying out of the market, regardless of product qualities.

Next, one considers whether it will be profitable for the entrant not only to enter the market, but also to sell the product to the incumbent. Appendix B also shows that if both firms are in the market and an OEM arrangement prevails, then both firms would prefer a high wholesale price w . If the incumbent is the Leader, the equilibrium is for the firms to agree on the highest price that still allows firms to serve all consumers and the incumbent to price-discriminate consumers (respect both $[IC_{\theta k}]$ and $[DD_\theta]$). This implies that the high wholesale price causes equilibrium prices for both firms to rise to the point that a *touching equilibrium* configuration (Economides 1984) emerges in the consumer segment that is targeted with the OEM product.

If the entrant is the Leader, the equilibrium wholesale price is even higher, causing the $[DD_\theta]$ constraint to be violated. In this case, the equilibrium configuration (which is a competitive equilibrium when firms go to market independently) becomes endogenously a local monopolistic equilibrium.

Neither an outcome with OEM only, nor an outcome in which the incumbent drops its own product can be an equilibrium because firms always have an incentive to enter the market with the products they possess. The reason is that a firm can always capture some additional profits from those consumers who locally prefer its brand image.

Discussion of the impact of horizontal differentiation

As presented above, the addition of horizontal differentiation changes firms' strategies and incentives with respect to the wholesale price. Below, we formalize and explain the results.

Proposition 2 *When brands are vertically and horizontally differentiated, the entrant will pursue a dual strategy (enter the market and also OEM). In this case:*

- (i) *When firms are local monopolists, they have unaligned incentives with respect to the wholesale price: if the incumbent is the Leader, it extracts all extra surplus by buying the OEM product at the production cost; if the entrant is the Leader, it extracts most (not necessarily all) of the extra surplus by selling the OEM product at a high wholesale price;*

⁷If the Differentiated Demand condition DD_θ is not satisfied, the equilibrium changes to incomplete market coverage.

(ii) *When firms can compete for consumers, they have nearly aligned incentives with respect to the wholesale price: if the incumbent is the Leader, it buys the product at the highest wholesale price that allows it to price discriminate consumers and firms to serve all consumers; if the entrant is the Leader, it sells the product at an even higher price, which induces firms to endogenously become local monopolists.*

Proof. In Appendix B. ■

It is not surprising that the addition of horizontal differentiation makes it profitable for the entrant to enter the market. After all, the demand-competition effect is weakened due to the brand image (horizontal) differentiation. It is less straightforward, however, to understand why both firms have a motivation to establish an OEM arrangement, and why it may be the case that both firms (the buyer and the seller) desire a high wholesale price.

To better explain the result, consider first the situation in which the **firms are local monopolists (item *i* above)**. In this situation, firms do not compete for the same consumers, thus an OEM arrangement does not increase nor decrease competition between the firms (the demand-competition effect is null). Nevertheless, the OEM arrangement does have a beneficial effect for the firms. It allows the incumbent to extract additional consumer surplus by targeting different consumer segments with different market offerings, thus activating the surplus-extraction effect.

If the incumbent is the Leader, it keeps all the extra surplus from the OEM arrangement by offering to buy the OEM product at a price that is barely above its production cost. The entrant accepts the arrangement since it is not worse than rejecting it. On the other hand, if the entrant is the Leader, it prefers to sell the product at a high price, but it may not be able to extract all the extra surplus. The reason is that the entrant faces the double marginalization problem with respect to sales on the incumbent's captive market: an attempt to extract all of the rents from the incumbent would decrease consumer demand to sub-optimal levels, due to a sequence of mark-ups that leads to excessive prices to end consumers. Thus, even if the entrant has the power to impose the highest price that makes the incumbent barely indifferent about selling the product or not, under many parametric scenarios, the entrant would decide not to do so.

Therefore, we conclude that, for high degrees of horizontal differentiation, because firms do not compete, the OEM arrangement is driven by the market-access and surplus-extraction effects. OEM is simply a method for a producer to find a different outlet for its product, and for the buyer to expand its product line. One could view the ensuing arrangement as equivalent to a situation in which a manufacturer sells directly in a territory and also sells as a private-label supplier to a retailer in another exclusive territory.

Next, we focus on the more intriguing result that occurs when the **firms can compete for consumers (item *ii* above)**. In this situation, an OEM arrangement with a high wholesale price is beneficial to both firms. To better explain this result, the scenario in which the incumbent has a high objective-quality product and the entrant has a low objective-quality product will be used (the explanation for the reverse situation is similar). If the entrant enters the market and no OEM arrangement is established, both firms compete with one product each for the two consumer segments. The incumbent will sell mostly to choosy consumers, but it still wants to sell its product to some of

the cheap consumers who strongly prefer its brand. Similarly, the entrant will sell mostly to cheap consumers, but still wants to target some of the choosy consumers who locally prefer its brand. This means that firms set an “average” price, that makes a compromise between the two segments.

When an OEM arrangement is considered, the incumbent wants to buy the product because it helps the firm to price-discriminate consumers: the incumbent can sell its own product to choosy consumers and the OEM product to cheap consumers (activating the surplus-extraction effect). From the entrant’s viewpoint, selling its product to the incumbent effectively increases competition within the cheap consumers segment, since both firms are selling products to these consumers (the demand-competition effect for cheap consumers increases). However, because the incumbent now sells two products, it can increase the price of its own product (the demand-competition effect for choosy consumers is relaxed). The OEM arrangement thus causes the entrant to experience a negative competitive effect for cheap consumers and a positive competitive effect for choosy consumers.

For an OEM with entry to become truly profitable, another factor needs to be pondered: the price-increasing effect. As shown in Appendix B, an increase in w causes the incumbent to increase the consumer price of the low-quality product. Due to the strategic complementarity of prices, an increase in w indirectly causes the entrant to also increase consumer prices. This ultimately feeds back on the incumbent’s consumer price for the high-quality product. It is, therefore, the compounding effect of strategic complementarity of prices that drives the result: An increase in w causes an “across-the-board” increase in consumer prices that allows firms to obtain more profits. Hence, firms incentives on OEM contracting are aligned and both prefer a high wholesale price (up to a certain threshold). If, however, prices are so high that firms effectively become local monopolies, the benefit of the price-increasing effect vanishes and the incumbent starts experiencing decreasing profit outcomes as a function of wholesale prices, while the entrant may still benefit from further wholesale price increases due to direct revenue effects from sales of that product.

Although firms incentives are not perfectly aligned, this case is an example of competing self-interested firms being able to reach a mutually beneficial outcome. By acting non-cooperatively according to their best interests, firms reach an equilibrium in which they accord with each other when establishing an OEM agreement with a high wholesale price, even if they compete with each other when selling the product to consumers. This outcome is significantly better than the one that would ensue if firms were not to agree on an OEM arrangement. It is also interesting to notice that this case is also an example of a bilateral relationship outcome in which the Stackelberg Leader does not benefit substantially more from the vertical relationship than the Follower does.

The aforementioned example of EMC selling enterprise storage products to its customers and also to HP illustrates this situation. As reported by Zhu (2000), both EMC and HP were members of the “Big Six” storage vendors, with EMC being the market leader. EMC and HP have well-known and distinctive brands (thus the horizontal differentiation). Furthermore, HP was producing entry-level storage systems, while EMC was producing mid-level to high-end storage systems (thus the vertical differentiation). Even though both companies competed in the U.S. market, through the OEM relationship, HP was able to fill gaps in its product line, while EMC was able to penetrate the market of customers who prefer to buy from HP.

5 Extension: Endogenous product qualities

In this section, we extend the model by endogenizing firms' product quality decisions and considering that the firms have the capability of producing both the high- and the low-quality products. Each firm thus has four possibilities regarding its production decision: to produce no product, only a high-quality product, only a low-quality product, or both products. We also consider that not only the entrant, but also the incumbent can OEM one or both of the products to the other firm.

To accommodate the firms' endogenous production decision we revise the structure of the game (described in §2): In the first stage, the entrant makes the OEM/Entry decision. In the second stage, firms make production decisions simultaneously.⁸ In the interim, if firms engage in an OEM arrangement, the wholesale prices are decided by a take-it-or-leave-it offer from the Leader to the Follower. In the third stage, each firm sets the price of its products to consumers and demand is realized. As before, the solution concept follows the principle of sequential rationality.

Given that much of the structure of the game is similar to that in the previous sections, we review the scenarios in the paper in a concise manner (derivations are in the appendices C and D).

5.1 Endogenous qualities: vertical differentiation only

The considerations regarding demand and separation prices are similar to those in §3. Here, however, the firm's costs of producing the high-quality product affects the competitive landscape. The following proposition states the ensuing equilibrium:

Proposition 3 *When firms can produce both products and are horizontally undifferentiated:*

- *If $c_{iH} < c_{eH}$, then the entrant stays out of the market and no OEM relationship is established.*
- *If $c_{iH} > c_{eH}$, then the entrant stays out of the market and OEMs the high-quality product to the incumbent.*

In this configuration, firms have unaligned incentives with respect to the wholesale price: if the incumbent (entrant) is the Leader it extracts all extra surplus by buying (selling) the OEM product at a low (high) wholesale price.

Proof. In Appendix C. ■

The rationale behind this proposition is as follows: When the incumbent is alone in the market, it will be producing both products, since this allows the incumbent to price-discriminate consumers on its own.

Because firms are on equal footing with respect to the value and the cost of the low-quality product, if the entrant were to enter the market with this product, the lack of horizontal differentiation would yield the standard Bertrand outcome in which firms accrue zero profit from consumers targeted with the low-quality product. Therefore, the entrant entering the market with the low-quality

⁸We still employ the labeling of incumbent and entrant to identify firms. However, because both firms can adjust their production decisions after the entrant's entry decision, the distinction between the two firms is less consequential.

product does not constitute a credible threat that forces the incumbent to buy the entrant's product (the entrant will not enter if expected profits are zero). Furthermore, because both firms have the same production cost, firms cannot achieve higher efficiencies by agreeing on an OEM arrangement.

With respect to the high-quality product, when the incumbent has a cost advantage ($c_{iH} < c_{eH}$), if the entrant were to enter the market with the high-quality product, the incumbent would find it optimal to price just below c_{eH} and capture the entire segment of consumers targeted with the high-quality product. This means that the entrant cannot earn positive returns by entering the market and competing with the incumbent, thus it stays out of the market.

On the other hand, when the entrant has a cost advantage ($c_{iH} > c_{eH}$), then the entrant could enter the market and earn positive profit (to see this, notice that the entrant could price the high-quality product at a price \bar{p}_e just below c_{iH} and capture the entire segment of consumers who buy this product). However, firms can extract more surplus from consumers if the entrant stays out of the market and supplies the high-quality product to the incumbent in an OEM arrangement. Such arrangement not only reduces the overall production cost of the product, but also voids the demand competition effect. In conclusion, OEM of the high-quality product from the entrant to the incumbent becomes an equilibrium not only because the threat of entry is credible, but also because firms achieve higher production efficiencies.

As in the single product case (§3), firms have unaligned incentives with respect to the wholesale product. The incumbent (buyer) wants to pay as little as possible, while the entrant (seller) wants to sell as high as possible. In any event, all of the extra surplus from the OEM arrangement is captured by the Stackelberg Leader. If the incumbent is the Leader, it will offer to buy the product at a wholesale price that makes the entrant barely indifferent about the strategy of entering the market and competing with the incumbent and the strategy of staying out of the market and supplying the product to the incumbent. Conversely, if the entrant is the Leader, it will offer to sell the product at a wholesale price that makes the incumbent barely indifferent about the strategy of competing with the entrant and the strategy of buying the product from the entrant and acting as a monopolist in the market .

A specific example of this case is the strategy of TSMC, the world's largest independent semiconductor foundry, which is able to produce with varying quality levels. The company elected not to enter the market on its own, but to produce chips for other companies such as ATI, Broadcom, and NVIDIA (see Mathews 2002 and TSMC's 2007 Annual Report⁹).

5.2 Endogenous qualities: the impact of horizontal differentiation

The procedure to compute demands and equilibrium prices and profits for the firms are similar to that in §4. As in the previous horizontally-differentiate cases, the difference in brand images allows both firms to serve consumers who strongly prefer their respective brand; thus, the entrant will always find it optimal to enter the market. Here, however, the possibility that firms can produce both products on their own significantly changes the overall strategy of the firms.

⁹Available from TSMC's website <http://www.tsmc.com/english/default.htm>

When the transportation cost is very high, so that firms do not compete for consumers, the low-cost producer of the high-quality product will OEM the product to the other firm.

When the transportation cost is moderate, and firms compete for consumers, our analysis reveals that, even if firms have the capacity to produce and market both quality levels, each firm will endogenously select to produce just one type of product and to differentiate its product from that produced by the competitor. Furthermore, firms will decide to buy each other's products.

The proposition below formally states the ensuing equilibrium.

Proposition 4 *When firms can produce both products and are horizontally differentiated, then the entrant enters the market. In this case:*

- (i) *When firms are local monopolists, both firms produce the low-quality product, and the most efficient producer OEMs the high-quality product to the other company. Furthermore, firms have unaligned incentives with respect to the wholesale price: if the incumbent (entrant) is the Leader, it extracts all (most) of the extra surplus by buying (selling) the OEM product at a low (high) wholesale price;*
- (ii) *When firms can compete for consumers, they will choose to produce just one product each, with distinct qualities. Firms will become OEM suppliers to each other, allowing each firm to sell both the high- and the low- quality products to consumers. Furthermore, firms' incentives for the wholesale prices are strongly aligned: both firms desire the low-quality product to command the highest price that still allow firms to serve all consumers, and the high-quality product to command high prices that still allows firms to price discriminate consumers.*

Proof. In Appendix D. ■

As in the previous horizontally-differentiated cases, the difference in brand images allows the entrant to enter the market and serve those consumers who locally prefer its brand.

When firms are local monopolists (item *i* above), there is no demand-competition effects, and OEM is driven by cost efficiency considerations. The rationale is as follows: With respect to the low-quality product, firms do not see any advantage from buying from one another. Therefore, both firms will produce the low-quality product and sell to cheap consumers of their captive markets.

With respect to the high-quality product, equilibrium results are driven by the relative magnitude of the firms' production cost for that product. If $c_{kH} < c_{-kH}$ then firm k will OEM the product to firm $-k$. The rationale is that the high-cost producer can save on costs by buying from the low-cost producer. We also notice that if firm k , the low-cost producer, is the Leader it should offer to sell the product at a price barely below that of the other firms's marginal cost ($w^* = c_{-kH}$). If firm $-k$, the high cost producer, is the Leader, it will offer to buy the product at price barely above firm k 's marginal cost ($w^* = c_{kH}$). In both cases the Follower should accept, because it ends up with an outcome that is marginally better than the one from rejecting the offer.

When firms can compete for consumers, (item *ii* above), the result is very interesting. At first glance, it seems to be similar to that of Shaked and Sutton (1982). In that paper, firms endogenously select to produce products of different vertical qualities because it relaxes competition for consumers due to the fact that consumers with different taste preferences self-select to buy

products of varying qualities offered by different firms. In our result, however, differences in product manufacturing are not carried over to differences in the quality of the products offered to consumers (both firms offer both product qualities), thus the differentiation of the products in a heterogenous market is not the reason behind the relaxation in price competition. Our results are driven by a different mechanism, which is explained below.

Consider firm k 's incentives. The ability to produce both products allows the firm to target each segment of consumers independent of the other firm. Thus, the firm may consider whether to challenge the other firm with its own products or to OEM the product. If firm k goes after consumers directly, it realizes that to capture consumers whose ideal brand preference points are located away from its brand image location, it has to reduce prices. In addition, whenever a firm loses a customer to the competitor, the revenues from that customer are totally lost, thus making each consumer very valuable and the firm more aggressive in competing for the marginal consumer. These two effects compound and end up depressing consumer prices and firms' profits.

Conversely, if firm k sells the product to the competitor in an OEM arrangement, and allows the competitor to serve those consumers who strongly prefer its ($-k$'s) brand, firm k avoids the need to reduce prices to capture consumers whose ideal brand preference points are located away from firm k 's brand image location. Furthermore, firm k also receives some revenue through the wholesale price paid by the competitor, which makes not only firm k less aggressive about pursuing the marginal consumer (since firm k will get a fraction of the revenue anyway), but also the competitor less aggressive because it needs to give up part of the revenue to the OEM supplier. The conclusion is that both firms find the marginal consumer less "valuable" when they engage in an OEM arrangement than when they do not. Lastly, when firms supply to each other, they realize that low prices in a segment would force prices in the other segment to be low as well because of the *Incentive Compatibility* constraints, thus further reducing the incentive for intense price competition. The compounding of these effects softens competition and causes an all across the board increase in consumer prices, which ultimately benefits both firms, and allows them to extract more surplus from consumers.

Appendix D shows that the incentive for high-prices is so high that it causes the wholesale price for the low-quality product to be at the highest price that still allows firms to serve all consumers ($w_L^* = v - \frac{3t}{2}$), thus creating an endogenous "touching equilibrium" configuration in the cheap consumers segment. Firms desire a high wholesale price for the high-quality product as well; however, this price is not high enough to cause a touching equilibrium in the choosy consumers segment. The reason is prices are bounded by the by the *Incentive Compatibility* constraints that allow firms to price discriminate consumers ($w_H^* \in [v + \Delta - \frac{3t}{2}, v + \bar{\theta}\Delta - \frac{3t}{2}]$).

An example of companies who sell products to each other is the case of the companies HUBER+SUHNER and SPINNER, two European leading brands in radio frequency measurement technology which agreed to sell parts of each other's product lines.¹⁰

¹⁰Hubber+Shunner press release 03/07/2011, available at <http://www.hubersuhner.com/news>.

6 Discussion and conclusion

This research studied a market-entry model in which an entrant who possesses marketing capabilities has the opportunity to enter the market and compete with the incumbent and/or sell its product to the incumbent in an OEM arrangement. The paper considered different scenarios of firm characteristics and consumers' heterogeneous preferences for brand image and quality valuations. The contribution of the paper lies in showing that these elements can exert an important influence in shaping a firm's entry and OEM decisions, according to a number of conditions. The conditions and how they change the entrant's incentive to pursue each strategy are summarized in Figure 1 below.

Degree of differentiation	Exogenous product quality (single product firms)	Endogenous product quality (firms can produce both product qualities)
Vertical Only	<p>OEM only: A</p> <ul style="list-style-type: none"> - entrant OEMs to incumbent. <p>Unaligned incentives w.r.t. w:</p> <ul style="list-style-type: none"> - entrant leader implements high w; - incumbent leader implements low w. 	<p>Either no entry, or OEM only: B</p> <ul style="list-style-type: none"> - entrant OEMs to incumbent only if $c_{iH} > c_{eH}$. <p>Unaligned incentives w.r.t. w:</p> <ul style="list-style-type: none"> - entrant leader implements high w; - incumbent leader implements low w.
Vertical and Horizontal	<p>Local Monopolistic C</p> <p>OEM and Entry:</p> <ul style="list-style-type: none"> - entrant enters and OEMs to incumbent. <p>Unaligned incentives w.r.t. w:</p> <ul style="list-style-type: none"> - entrant leader implements high w; - incumbent leader implements low w. 	<p>OEM and Entry D</p> <ul style="list-style-type: none"> - low c_{kH} firm OEMs to high c_{kH} firm. <p>Unaligned incentives w.r.t. w:</p> <ul style="list-style-type: none"> - entrant leader implements high w; - incumbent leader implements low w.
Vertical and Horizontal	<p>Competitive E</p> <p>OEM and Entry:</p> <ul style="list-style-type: none"> - entrant enters and OEMs to incumbent <p>Nearly-aligned incentives w.r.t. w:</p> <ul style="list-style-type: none"> - firms implement high w. 	<p>OEM and Entry: F</p> <ul style="list-style-type: none"> - firms OEM to each other. <p>Strongly-aligned incentives w.r.t. w:</p> <ul style="list-style-type: none"> - firms implement high w.

Figure 1: Entrant's strategy and Firms' standpoint on wholesale prices

The underlying forces behind the results are as follows:

When consumers perceive the firms' brand images as similar (horizontally undifferentiated), entry by the entrant would trigger very intense competition by the incumbent. Because of this, it is better for the entrant to stay out of the market. The entrant may nevertheless OEM the product to the incumbent if (A) it produces a product quality that the incumbent is not able to produce on its own, in which case the entrant helps the incumbent to complement its product portfolio and extract surplus from consumers; or (B) it produces similar qualities as the incumbent does, but the entrant has a cost advantage that makes it worthwhile for the incumbent to stop production and allow the entrant to become the supplier, in which case the main driver is the search for production efficiencies.

When consumers perceive the firms' brand images as different (and thus they possess a significant degree of horizontal differentiation), the entrant always has an incentive to enter the market. The reason is that the brand image differences soften the market competition and make it profitable for the entrant to enter. Market entry by the entrant does not preclude firms from engaging in OEM

relationships, though. It is not surprising that firms may decide to engage in these relationships when they are local monopolists, in which case selling products to the other firm does not affect the supplier firm's own captive market. In these situations, OEM relationships are either (*C*) a means that firms have to serve other markets or segments that they could not adequately tap on their own; or (*D*) a means to achieve a better efficiency by buying from a more efficient producer.

A more surprising result is that firms will find it optimal to engage in OEM relationships even when they are direct competitors for some of the consumers. The reason for this interesting result is that, instead of increasing competition, OEM to a rival firm can be a tool to better price-discriminate consumers and to decrease the competitive pressure on prices. In these situations (*E*) when firms products have different qualities, OEM for a product that serves one of the segments acts as a commitment device that decreases competitive pressure in the other segment; or (*F*) when firms can match each other's qualities OEM can serve as a mechanism that weakens the overall competition in the market because it reduces the differential marginal return of a consumer, thus making firms less aggressive when attempting to generate demand from the contested consumers. In both cases the overall result is an increase in profit for both firms.

Consumer Welfare

An inspection of the consumer utilities given equilibrium outcomes reveals that the addition of horizontal differentiation may either increase or decrease consumer welfare depending on the parameters. The reason is that horizontal differentiation has two countervailing effects: on the one hand, it benefits consumers because it allows the entrant to enter the market, which reduces the overall equilibrium prices (despite the fact that high wholesale prices soften price competition); on the other hand, it increases the consumers' disutility from purchasing a product that does not match their brand image preferences. In general, a switch from vertical differentiation only to vertical and horizontal differentiation increases the welfare of consumers whose brand image preferences closely match the positioning image of one of the firms (because they enjoy the reduction in prices due to increased firm competition without experiencing high transportation cost disutilities), and decreases the welfare of consumers whose brand image preferences are located away from both brands (because they suffer the bulk of the transportation cost disutilities).

Robustness, limitations, and future research

Perhaps the most noticeable assumption in the model is the distribution of consumers in a Hotelling market. This is not a major limitation, since the qualitative model's results are valid for other market structures and demand systems. For instance, the entry and OEM decision results extend without changes to a circular-city market model. Results also extend to differentiated and undifferentiated Bertrand demand specifications with the following caveat: If the cross-price effect is not too small in comparison to the own-price effect, then the results do not change. If, on the other hand, the cross-price effect is small in comparison to the own-price effect, then the qualitative results of entry and OEM are the same, although in the differentiated case, firms will agree on an "intermediate" wholesale price. This is because the seller still desires a high price for its product, but the buyer desires to pay a small price, since for this firm, the price-increasing and surplus-extraction effects no longer overpower the demand-competition effect.

In our model, the OEM contracting between firms is based on the wholesale price only, a type of contract that is very conventional and tend to be administratively cheaper than other forms of contracts (Cachon and Lariviere 2005). Although in some situations wholesale-price-only contracts may be less efficient in terms of coordinating the channel, this type of contract is not a limitation of our model because the qualitative results are robust to other forms of vertical contracting (such as a two-part tariff contract). In the horizontally-undifferentiated cases, the final prices to consumers are not affected by different contractual forms: the contractual terms only have the function of transferring surplus from the Follower to the Leader. In the competitive horizontally-differentiated cases with full market coverage, the high wholesale price is a tool to reduce price competition, thus firms have no incentive to substitute wholesale prices by some other contractual terms. In fact, the use of other contractual terms that decrease the marginal transactional cost of the product is clearly undesirable for both firms. In the local monopolistic horizontally-differentiated cases, the qualitative results would be the same, although firms could improve their outcomes by adopting a two-part tariff contract. The reason is that, in this equilibrium configuration, a wholesale-price-only contract gives rise to a double marginalization problem, which could be reduced by a two-part tariff contract.

Another issue of interest is whether a forward looking incumbent could set a pricing strategy that prevents a particular entrant strategy. Given the current structure of the model, this is not endogenously profitable for the incumbent. However, if additional elements were incorporated into the model, such a strategy could become profitable. Future research can expand upon our model and include elements from the *entry-deterrence* literature (such as information asymmetries, increasing efficiencies, erection of entry barriers, etc.) to investigate how an incumbent could influence entry and OEM strategies of a potential entrant.

Managerial implications

This research not only has theoretical, but practical relevance as well. A large number of companies have design, production, and marketing capabilities and may entertain the possibility of entering a new market. Managers responsible for these types of decisions have to consider carefully which strategy would be best for their companies. As the results of this research suggest, the answer depends on the competitive landscape the products are likely to face, the quality of the firm's products relative to the quality of the products in the market, and whether the firm's brand image could establish a meaningful differentiation element in the eyes of consumers. Our findings also have relevance for firms' production decisions. We find that at times, firms may decide to differentiate production even if they end up selling equivalent product lines to consumers.

The research also provides insights that can help guide a potential entrant's decisions regarding choice of product features. Common wisdom tells us that firms should focus on features that meet consumer needs; yet, the model's results suggest that a potential entrant with an undifferentiated brand may profit more by focusing on product features that help the incumbent to fill its product line, so that the incumbent can price-discriminate across consumer segments better.

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Appendix

Throughout this appendix, we employ the symbol ε to represent an infinitesimal amount.

A Proof of Proposition 1

Analysis of the second stage

Outcomes for entry only. There is no pure-strategy Nash Equilibrium for entry only. To see this, consider the following. If the low-quality firm pursues cheap consumers with a price p , the high-quality firm may choose to pursue all consumers by pricing slightly below $p + \Delta$, or it may choose to pursue choosy consumers only by pricing at $p + \bar{\theta}\Delta$. Formally, the high-quality firm pursues all consumers when $(p + \Delta - c_{kH}) \geq \lambda(p + \bar{\theta}\Delta - c_{kH})$. We solve this expression with equality for p and define $p_{kH}^{indif} \equiv \frac{\lambda}{1-\lambda}(\bar{\theta} - 1)\Delta + c_{kH}$ as the minimum price the high-quality firm is willing to set so as to compete for cheap consumers. Similarly, we define $p_{kL}^{indif} \equiv \frac{1-\lambda}{\lambda}(\bar{\theta} - 1)\Delta + c_{kL}$ as the minimum price the low-quality firm is willing to set so as to compete for choosy consumers.

For the high-quality firm, any price $p_{kH} > p_{kH}^{indif}$ cannot be an equilibrium because the firm is able to lower its price so as to capture cheap consumers. This causes firms to undercut each other's prices until the high-quality firm's price reaches p_{kH}^{indif} . At this point, the high-quality firm prefers to target choosy consumers only and set the price $p_{kH} = \min\{p_{kH}^{indif} + (\bar{\theta} - 1)\Delta, v + \bar{\theta}\Delta\}$. This, in turn, allows the low-quality firm to increase its price to just below $p_{kL} = \min\{p_{kL}^{indif} + (\bar{\theta} - 2)\Delta, v\}$. Such a move by the low-quality firm reignites the price competition for choosy consumers. By the same rational, any low-quality firm price $p_{kL} > p_{kL}^{indif}$ cannot be an equilibrium, because if the low-quality firm sets a price $p_{kL} < p_{kH} - \bar{\theta}\Delta$, so as to capture all consumers, the high-quality firm can set a price $p_{kH} = p_{kL} + \bar{\theta}\Delta$ to recapture choosy consumers. Firms can undercut each other in this fashion up to the point at which $p_{kL} < p_{kL}^{indif}$, and the low-quality firm jumps to $p_{kL} = p_{kH} - \Delta$. This would cause the high-quality firm to readjust its price upward again and the price-cutting cycle resumes.

However, in this competitive scenario, there is an equilibrium in mixed strategies as follows: The low-quality firm randomizes its price according to some density $F_{kL}[p]$, and the high-quality firm according to some density $F_{kH}[p]$. such that firms are indifferent to any feasible price in the action profile domain. To characterize these price-density functions, and the associated expected payoffs for the firms, one starts by determining the support of the price densities. The supports depend on whether $p_{kH}^{indif} < p_{kL}^{indif}$ or $p_{kH}^{indif} > p_{kL}^{indif}$. We define $\bar{\lambda} \equiv \frac{c_{kH} + (2\bar{\theta} - 1)\Delta - \sqrt{(c_{kH} - \Delta)^2 - 4\bar{\theta}\Delta^2 + 4\bar{\theta}^2\Delta^2}}{2c_{kH}}$, and notice that because $p_{kH}^{indif} = \frac{\lambda}{1-\lambda}(\bar{\theta} - 1)\Delta + c_{kH}$, and $p_{kL}^{indif} = \frac{1-\lambda}{\lambda}(\bar{\theta} - 1)\Delta$, when $\lambda < \bar{\lambda} \Rightarrow p_{kH}^{indif} < p_{kL}^{indif}$, and $\lambda > \bar{\lambda} \Rightarrow p_{kH}^{indif} > p_{kL}^{indif}$.

Considering first the situation in which $\lambda < \bar{\lambda}$, we determine $F_{kL}[p]$. In this situation, the low-quality firm never needs to price below $p_{kH}^{indif} - \Delta$. Furthermore, given that if the other firm deviates to serve only choosy consumers it optimally does so by charging $p_{kH}^{indif} + (\bar{\theta} - 1)\Delta$, the low-quality firm never prices above $p_{kH}^{indif} + (\bar{\theta} - 2)\Delta$, because doing so means that it captures no consumer. The lowerbound constraint in the price-density function of the low-quality firm is its own marginal cost

(i.e.: 0) and the upperbound is the maximum price it sets when pursuing cheap consumers (i.e.: v). Consequently, the support of $F_{kL}[p]$ is the range $[\max\{p_{kH}^{indif} - \Delta, 0\}, \min\{p_{kH}^{indif} + (\bar{\theta} - 2)\Delta, v\}]$.

Now, we can construct $F_{kL}[p]$. The low-quality firm's price density should be such that:

$$\pi_{kH}^{entry} = (1 - \lambda)(p_{kH} - c_{kH})(1 - F_{kL}[p_{kH} - \Delta]) + \lambda(p_{kH} + (\bar{\theta} - 1)\Delta - c_{kH})(1 - F_{kL}[p_{kH} - \Delta]) = \zeta, \quad (A1)$$

where ζ is a constant that captures the profit for the high-quality firm.

The term $(1 - \lambda)(p_{kH} - c_{kH})(1 - F_{kL}[p_{kH} - \Delta])$ represents the high-quality firm's profit from cheap consumers (when $p_{kH} < p_{kL} - \Delta$), while the term $\lambda(p_{kH} + (\bar{\theta} - 1)\Delta - c_{kH})(1 - F_{kL}[p_{kH} - \Delta])$ represents the high-quality firm's profit from choosy consumers (when $p_{kH} < p_{kL} - \bar{\theta}\Delta$). Given the density support, we can determine that $F_{kL}[p_{kH}^{indif} - \Delta] = 0$. Furthermore, by replacing p_{kH} and p_{kL} with p and solving equation (A1) for $F_{kL}[p - \Delta]$ we obtain: $F_{kL}[p - \Delta] = 1 - \frac{\zeta}{p - c_{kH} + \lambda(\bar{\theta} - 1)\Delta}$.

By using the condition that $F_{kL}[p] = 0$ for $p = p_{kH}^{indif} - \Delta$, we find that $\zeta = \left(\frac{1 - \lambda + 2\lambda(\bar{\theta} - 1) - \lambda^2(\bar{\theta} - 1)}{1 - \lambda}\right) \Delta$, and consequently, $F_{kL}[p] = \frac{(1 - \lambda)(p - c_{kH}) - (\bar{\theta} - 1)\Delta}{1 - \lambda}$.

The full specification of the low-quality firm's price density thus is:

$$F_{kL}^*[p] = \begin{cases} 0 & \text{if } p \leq 0 \\ \frac{(1 - \lambda)(p - c_{kH}) - \lambda(\bar{\theta} - 1)\Delta}{(1 - \lambda)[(p - c_{kH}) + \Delta + \lambda(\bar{\theta} - 1)\Delta]} & \text{if } 0 < p < v \\ 1 & \text{if } p \geq v \end{cases}.$$

Following a similar approach, we find that $F_{kH}[p]$ has support in the range $[p_{kH}^{indif}, \min\{p_{kH}^{indif} + (\bar{\theta} - 1)\Delta, v + \Delta\}] \cup (p_{kH}^{indif} + (\bar{\theta} - 1)\Delta)$, and is constructed as:

$$F_{kH}^*[p] = \begin{cases} 0 & \text{if } p \leq p_{kH}^{indif} \\ \frac{(2 - \lambda)[(1 - \lambda)(p - c_{kH}) - \lambda(\bar{\theta} - 1)\Delta]}{(1 - \lambda)[(2 - \lambda)(p - c_{kH}) - (\bar{\theta} + (1 - \lambda))\Delta]} & \text{if } p_{kH}^{indif} < p < \bar{\theta}\Delta + v \\ 1 & \text{if } p \geq \bar{\theta}\Delta + v \end{cases}.$$

This mixed-strategy price equilibrium yields expected profits for the firms of:

$$\underline{\pi}_{kH}^E = \left(\frac{1 - \lambda + (2\lambda - \lambda^2)(\bar{\theta} - 1)}{1 - \lambda}\right) \Delta, \quad \underline{\pi}_{kL}^E = \max\left\{0, \frac{(\bar{\theta}\Delta + c_{kH})(2 - 3\lambda + \lambda^2) - (\bar{\theta} - 1)\Delta}{1 - \lambda}\right\}$$

For the situation in which $\lambda > \bar{\lambda}$, one follows the the procedure above, with the difference that now p_{kL}^{indif} holds as the bottom line price that firms will need to set when they compete directly.

In this case, the mixed-strategy price equilibrium yields expected profits for the firms of:

$$\bar{\pi}_{kH}^E = (\bar{\theta}\Delta - c_{kH}) + \frac{(1 - \lambda)^2(\bar{\theta} - 1)\Delta}{\lambda}, \quad \bar{\pi}_{eL}^E = \max\left\{0, \frac{2(1 - \lambda)(\bar{\theta} - 1)\Delta}{\lambda}\right\}.$$

Outcomes for OEM only. The proof for the OEM-only outcomes follows a traditional Gains From Trade (GFT) proof. If the entrant stays out of the market and OEMs its product to the incumbent, then the incumbent can extract the maximum revenue from consumers by charging $p_i = v$ and $\bar{p}_i = \bar{\theta}\Delta + v$. Such revenue extraction is never inferior to that which could be obtained when firms compete for consumers. Consequently, there exists a wholesale price w such that: $\pi_i^O|w + \pi_e^O|w \geq \pi_i^E + \pi_e^E$, where $\pi_i^O|w$ is the OEM-only outcome and π_e^E is the entry-only outcome previously computed.

Because in the OEM-only firms do not compute, it is directly to conclude that $\frac{\partial \pi_i^O|w}{\partial w} < 0$ and $\frac{\partial \pi_e^O|w}{\partial w} > 0$. Therefore, if the incumbent is the Leader, it offers to buy the OEM product at the lowest price w^* that respects the GFT constraint that $\pi_e^O|w \geq \pi_e^E$. Conversely, if the entrant is the Leader,

it offers to sell the OEM product at a price w^* such that $\pi_i^O|w \geq \pi_i^E$. In both cases, the Follower firm accepts the contract since the GFT constraint is met.

Outcomes for OEM combined with entry. This entry strategy cannot be an equilibrium for the following reason:

Suppose the incumbent has a product and it buys the OEM product from the entrant (denoted as product o) to be resold in the market at price p_o . Suppose also that the entrant enters the market with the OEM product and sells it at price p_e . A price $p_e < w$ cannot be an equilibrium because of the straightforward reason that the entrant earns more by selling the product to the incumbent. A price $p_e > w$ is not an equilibrium because, according to standard Bertrand arguments, the incumbent can price product o at price p_o such that $w < p_o < p_e$ and capture the entire market. Lastly, the price $p_e = w$ is also not an equilibrium because the entrant suffers the infinitesimal cost of entering the market and gains no more profit than letting the incumbent take care of the market. Therefore there is no p_e that supports an equilibrium for the firms.

The incumbent drops its own product. If this strategy is adopted, then one possibility is for the incumbent to leave the market. That strategy can be ruled out because profits for the incumbent would be zero. Another possibility would be for both firms to sell the product produced by the entrant. This strategy can also be ruled out because the Bertrand outcome with zero profits for the incumbent would ensue in the pricing subgame (see Blume 2003).

Analysis of the first stage

Given the outcomes computed above, the entrant's optimal strategy is OEM only, and this is the unique equilibrium. In this outcome, firms have opposite incentives with respect to the wholesale price, which is set according to the computation of the OEM-only outcome derived above. ■

B Proof of Proposition 2

B.1 Firms are local monopolists

Analysis of the second stage

Outcomes for entry only. In this case, the firm's demands are obtained by finding, for each segment, all consumers who have positive utility from buying the product. For the incumbent, we solve $V(\theta, q_i) - p_i - tx_\theta = 0$ for x_θ . For the entrant, we solve $V(\theta, q_e) - p_e - t(1 - x_\theta) = 0$ for x_θ . In both cases, we find that consumer demand for a segment can be expressed as $\lambda\theta \frac{V(\theta, q_k) - p_k}{t}$.

If no OEM arrangement is established, firms target the two segments with a single product. Thus, the profit function for the firms is: $\pi_k = (p_k - c_k) \left(\lambda \frac{V(\bar{\theta}, q_k) - p_k}{t} + (1 - \lambda) \frac{V(\underline{\theta}, q_k) - p_k}{t} \right)$.

By taking derivatives w.r.t. prices and solving for the optimal prices, we find that $p_k^E = \frac{c_k + (1 - \lambda)V(\underline{\theta}, q_k) + \lambda V(\bar{\theta}, q_k)}{2}$, implying that the optimal outcome for the firms is $\pi_k^{E-mono} = \frac{[(1 - \lambda)V(\underline{\theta}, q_k) + \lambda V(\bar{\theta}, q_k) - c_k]^2}{4t}$.

Outcomes for OEM combined with entry. Below, we compute the outcomes for the case in which the incumbent produces a low-quality product and the entrant produces a high-quality product. The proof for the reverse situation is similar and thus it is suppressed.

If the incumbent buys the OEM product from the entrant and targets it to choosy consumers, the incumbent's profit is: $\pi_{iL} = (\bar{p}_i - w)\lambda \left(\frac{\bar{\theta}(v+\Delta) - \bar{p}_i}{t} \right) + (\underline{p}_i)(1 - \lambda) \left(\frac{v - \underline{p}_i}{t} \right)$.

The entrant has one product and targets both segments with the same product; hence, its profit from consumers is $(p_e - c_{eH}) \left[\lambda \left(\frac{\bar{\theta}(v+\Delta) - p_e}{t} \right) + (1 - \lambda) \left(\frac{(v+\Delta) - p_e}{t} \right) \right]$. However, the entrant also earns profit of $(w - c_{eH})\lambda \left(\frac{\bar{\theta}(v+\Delta) - \bar{p}_i}{t} \right)$ from selling the OEM product to the incumbent. The entrant's total profit thus is: $\pi_{eH} = (p_e - c_{eH}) \left[\lambda \left(\frac{\bar{\theta}(v+\Delta) - p_e}{t} \right) + (1 - \lambda) \left(\frac{(v+\Delta) - p_e}{t} \right) \right] + (w - c_{eH})\lambda \left(\frac{\bar{\theta}(v+\Delta) - \bar{p}_i}{t} \right)$.

By taking the first derivative of profit expressions π_{iL} and π_{eH} with respect to prices and simultaneously solving for the first order conditions, one obtains the consumer prices as a function of the wholesale price w : $\bar{p}_{iL}^{EO} = \frac{w + \bar{\theta}(v+\Delta)}{2}$, $\underline{p}_{iL}^{EO} = \frac{v}{2}$, $p_{eH}^{EO} = \frac{\lambda c_{eH} + [1 + \lambda(\bar{\theta} - 1)](v+\Delta)}{2}$.

When these prices are substituted into the firms' original profit expressions, profits for the firms, conditional on w , are obtained:

$$\begin{aligned} \pi_{iL}^{EO-mono}|w &= \frac{(1-\lambda)v^2 + \lambda[\bar{\theta}(v+\Delta) - w]^2}{4t}, \\ \pi_{eH}^{EO-mono}|w &= \frac{(v+\Delta - c_{eH})^2 + \{2\bar{\theta}w(v+\Delta) - 2w^2 + 2c_{eH}[(1-2\bar{\theta})(v+\Delta) + w] + (\bar{\theta}-1)(v+\Delta)[2 + (\bar{\theta}-1)\lambda]\lambda\}}{4t}. \end{aligned}$$

By taking derivatives of these profit expressions with respect to w , we find:

$$\frac{\partial \pi_{iL}^{EO-mono}|w}{\partial w} = \frac{\lambda[w - \bar{\theta}(v+\Delta)]}{2t}, \quad \frac{\partial \pi_{eH}^{EO-mono}|w}{\partial w} = \frac{\lambda[\bar{\theta}(v+\Delta) + c_{eH} - 2w]}{2t}.$$

Notice that $\frac{\partial \pi_{iL}^{EO-mono}|w}{\partial w} < 0$ because the expression $w - \bar{\theta}(v + \Delta)$ is necessarily negative for all admissible values of w because the maximum price a firm can charge choosy consumers is $v + \bar{\theta}\Delta$. Therefore, the incumbent desires the minimum wholesale price possible. However, the incumbent needs to provide to the entrant at least as much as the entrant can make by entering the market alone (i.e. meet the GFT constraint $\pi_{eH}^{EO-mono}|w \geq \pi_{eH}^E$). This implies that if the incumbent is the Leader, $w^* = c_{eH}$.

When examining $\frac{\partial \pi_{eH}^{EO-mono}|w}{\partial w}$, we find that the expression $\bar{\theta}(v + \Delta) + c_{eH} - 2w$ is positive for small values of w ; thus, the entrant wants a high wholesale price. An analysis of the prices above for the range of w that allows price discrimination (implements the $[IC_{\bar{\theta}}]$ conditions) reveals that for high wholesale prices, condition $[IC_{\bar{\theta}}]$ is violated because the incumbent's prices for the products grow further apart as w increases (notice that $\frac{\partial \bar{p}_{iL}^{EO}}{\partial w} = \frac{1}{2} > 0 = \frac{\partial \underline{p}_{iL}^{EO}}{\partial w}$). Therefore, the incumbent needs to "distort" its prices to meet the $[IC_{\bar{\theta}}]$ constraint. Distorted prices are obtained by maximizing the firms' profit function subject to the $[IC_{\bar{\theta}}]$ constraint:

$$\bar{p}_{iL}^{EO-IC} = \frac{2\bar{\theta}\Delta + (1+\lambda)\Delta + \lambda[\bar{\theta}(v-\Delta) + w]}{2}, \quad \underline{p}_{iL}^{EO-IC} = \frac{(1+\lambda)\Delta + \lambda[\bar{\theta}(v-\Delta) + w]}{2}, \quad p_{eH}^{EO-IC} = \frac{\lambda c_{eH} + [1 + \lambda(\bar{\theta} - 1)](v+\Delta)}{2}.$$

By substituting the distorted prices into the firms profit functions, we obtain:

$$\begin{aligned} \pi_{iL}^{EO-mono-IC}|w &= \frac{2\lambda v(w - \bar{\theta}\Delta)[1 - \lambda + \bar{\theta}\lambda(\lambda - 2)] + \lambda^2(w - \bar{\theta}\Delta)^2 + [\lambda(\bar{\theta} - 1)v + v]^2}{4t}, \\ \pi_{eH}^{EO-mono-IC}|w &= \frac{[1 + \lambda(\bar{\theta} - 1)]^2(v+\Delta)^2 + \lambda(1-\lambda)2(2\bar{\theta}-1)[vw - c_{eH}(2v+\Delta)] + \lambda^2\{c_{eH}^2 + 2(w - c_{eH})[\bar{\theta}(v+\Delta) - w]\}}{4t}. \end{aligned}$$

By taking derivatives of $\pi_{eH}^{EO-mono-IC}|w$ w.r.t. w and solving for the first order conditions, we find that the entrant's profit is maximized when $w = \frac{\lambda(\bar{\theta}\Delta + c_{eH}) + v[\bar{\theta}(2-\lambda) - 1 + \lambda]}{2\lambda}$. Thus we define $w^{FOC-mono}$ to be this value. However, the entrant may not be able to implement this value because it needs to provide to the incumbent an outcome that is at least as good as that the incumbent

can make by going alone (the GFT constraint $\pi_{iL}^{EO_mono_IC}|w \geq \pi_{iL}^{E_mono}$). Therefore, we define w^{GFT_mono} to be the wholesale price such that $\pi_{iL}^{EO_mono_IC}|w^{GFT_mono} = \pi_{iL}^{E_mono}$. By solving with equality for w^{GFT_mono} we find that $w^{GFT_mono} = \bar{\theta}\Delta$. Consequently, when the entrant is the Leader, the wholesale price will be $w^* = \min\{w^{FOC_mono}, w^{GFT_mono}\}$.

Lastly, we remark that the reason for the interior optimal price from the entrant's standpoint is the well known "double marginalization" phenomenon. Because the incumbent has local market power, it marks up the price of the product in direct relation to the wholesale price, thus maximum surplus extraction through the wholesale price will cause suboptimal consumer demand. An alternative solution to this problem could be the adoption of a two-part tariff contract between the incumbent and the entrant, in which case the entrant offers to sell the product at marginal cost ($w^* = c_{eH}$) and captures the surplus through a fixed fee.

Outcomes for OEM only. For the entrant, the strategy of OEM only is strictly dominated by OEM combined with entry, because the firm can always increase profit by entering the market and selling to those consumers who locally prefer its brand.

The incumbent drops its own product. The incumbent always have an incentive to target the consumers who locally prefer its own brand. Thus, the strategy of dropping its own product is strictly dominated by OEM combined with entry because, in the latter strategy, the incumbent can price-discriminate consumers by selling two different profits.

Analysis of the first stage

Given the outcomes above, the best strategy for the entrant is to enter the market and also to OEM its product to the incumbent. In this outcome, firms have opposite incentives with respect to the wholesale price, which is set according to the computations in the OEM-and-entry case.

B.2 Firms can compete for consumers

Analysis of the second stage

Outcomes for entry only. In this case, firms' demands are obtained by finding, for each segment, the consumer who is indifferent about buying from either firm. In other words, the indifference point x_θ^* be such that the utility gained by purchasing the incumbent's or the entrant's product is equal. We solve $V(\theta, q_k) - p_k - tx_\theta = V(\theta, q_{-k}) - p_{-k} - t(1 - x_\theta)$ for x_θ and find that $x_{\theta k}^* = \frac{1}{2} + \frac{(V(\theta, q_k) - V(\theta, q_{-k})) - (p_k - p_{-k})}{2t}$. This expression is true, provided the $[DD\theta]$ conditions are satisfied.

By using the indifference point above, one can write the firms' profit expressions as:

$$\pi_k = (p_k - c_k) \left[\lambda \left(\frac{1}{2} + \frac{(V_{\bar{\theta}k}(\cdot) - V_{\bar{\theta}-k}(\cdot)) - (p_k - p_{-k})}{2t} \right) + (1 - \lambda) \left(\frac{1}{2} + \frac{(V_{\underline{\theta}k}(\cdot) - V_{\underline{\theta}-k}(\cdot)) - (p_k - p_{-k})}{2t} \right) \right].$$

By taking derivatives w.r.t. prices and simultaneously solving the first order conditions for p_k , the optimal prices for the firms are obtained: $p_k^E = t + \frac{2c_k + c_{-k} + \lambda[V(\bar{\theta}, q_k) - V(\bar{\theta}, q_{-k})] + (1 - \lambda)[V(\underline{\theta}, q_k) - V(\underline{\theta}, q_{-k})]}{3}$.

Once these prices are substituted back into the original profit expressions, the optimal profits for the firms can be expressed as: $\pi_k^{E-comp} = \frac{\{3t-c_k+c_{-k}+\lambda[V(\bar{\theta},q_k)-V(\bar{\theta},q_{-k})]+(1-\lambda)[V(\underline{\theta},q_k)-V(\underline{\theta},q_{-k})]\}^2}{18t}$.

Outcomes for OEM combined with entry. Below, we compute the outcomes for the case in which the incumbent produces a low-quality product and the entrant produces a high-quality product. The proof for the reverse situation is similar and thus it is suppressed.

Considering that the incumbent buys the high-quality product from the entrant, and directs the high-quality product to choosy consumers, and its own low-quality product to cheap consumers, the incumbent's profit expression is: $\pi_{iL} = (\bar{p}_i - w)\lambda \left(\frac{1}{2} - \frac{(\bar{p}_i - p_e)}{2t}\right) + (p_i)(1 - \lambda) \left(\frac{1}{2} - \frac{\Delta + (p_i - p_e)}{2t}\right)$.

The entrant has one product and targets both segments with it; hence its profit from consumers is $(p_e - c_{eH}) \left[\lambda \left(\frac{1}{2} + \frac{(\bar{p}_i - p_e)}{2t}\right) + (1 - \lambda) \left(\frac{1}{2} + \frac{\Delta + (p_i - p_e)}{2t}\right)\right]$. The entrant also earns profit of $(w - c_{eH})\lambda \left(\frac{1}{2} - \frac{(\bar{p}_i - p_e)}{2t}\right)$ from selling the OEM product to the incumbent. The entrant's overall profit thus is: $\pi_{eH} = (p_e - c_{eH}) \left[\lambda \left(\frac{1}{2} + \frac{(\bar{p}_i - p_e)}{2t}\right) + (1 - \lambda) \left(\frac{1}{2} + \frac{\Delta + (p_i - p_e)}{2t}\right)\right] + (w - c_{eH})\lambda \left(\frac{1}{2} - \frac{(\bar{p}_i - p_e)}{2t}\right)$.

By taking the first derivative of profit expressions π_{iL} and π_{eH} w.r.t. prices and simultaneously solving for the first order conditions, one obtains the consumer prices as a function of the wholesale price w :

$$\bar{p}_{iL}^{EO} = t + \frac{(1-\lambda)(\Delta+2c_{eH})+3(1+\lambda)w}{6} \quad \underline{p}_{iL}^{EO} = t + \frac{2(1-\lambda)c_{eH}-(2+\lambda)\Delta+3\lambda w}{6}, \quad p_{eH}^{EO} = t + \frac{(1-\lambda)(\Delta+2c_{eH})+3\lambda w}{3}.$$

An analysis of the prices above for the range of w that allows price discrimination (implements $[IC_{\bar{\theta}}]$) reveals that for high wholesale prices, condition $[IC_{\bar{\theta}}]$ is violated (notice that both firms will prefer high wholesale prices and that $\frac{\partial \bar{p}_{iL}^{EO}}{\partial w} = \frac{1+\lambda}{2} > \frac{\lambda}{2} = \frac{\partial \underline{p}_{iL}^{EO}}{\partial w}$; hence, the incumbent's prices for the products grow further apart as w increases). Therefore, the incumbent needs to "distort" its prices to meet the $[IC_{\bar{\theta}}]$ constraint. Distorted prices are obtained by maximizing the firms' profit function subject to the $[IC_{\bar{\theta}}]$ constraint: $\bar{p}_{iL}^{EO-IC} = \bar{\theta}\Delta + t + \frac{(1-\lambda)(c_{eH}-\Delta)+3\lambda(c_{eH}-\bar{\theta}\Delta)}{3}$, $\underline{p}_{iL}^{EO-IC} = t + \frac{(1-\lambda)(c_{eH}-\Delta)+3\lambda(c_{eH}-\bar{\theta}\Delta)}{3}$, $p_{eH}^{EO-IC} = t + \frac{(1-\lambda)(\Delta+2c_{eH})+3\lambda w}{3}$.

When the constrained prices are substituted into the firms' original profit expressions, profits for the firms, conditional on w , are obtained:

$$\pi_{iL}^{EO-comp-IC}|w = \frac{9t^2+(1-\lambda)[6t(c_{eH}-\Delta)+9\Delta(\bar{\theta}-1)(w-\bar{\theta}\Delta)+(1-\lambda)(c_{eH}-\Delta)^2]}{18t},$$

$$\pi_{eH}^{EO-comp-IC}|w = \frac{9t^2+18\lambda tw-(6+3)tc_{eH}+(1-\lambda)[6t\Delta+9\lambda(\bar{\theta}-1)\Delta(w+c_{eH})+(1-\lambda)(c_{eH}-\Delta)^2]}{18t}.$$

By checking the $[DD_{\theta}]$ conditions, we find that they are met whenever $w \leq \frac{2v+(1+\bar{\theta}\lambda)\Delta-3t-(1-\lambda)c_{eH}}{2\lambda}$, thus we define $w^{DD} \equiv \frac{2v+(1+\bar{\theta}\lambda)\Delta-3t-(1-\lambda)c_{eH}}{2\lambda}$. For all $w < w^{DD}$ the competitive outcome will ensue.

We take derivatives of $\pi_{iL}^{EO-comp-IC}|w$, and $\pi_{eH}^{EO-comp-IC}|w$ with respect to w , and find that:

$$\frac{\partial \pi_{iL}^{EO-comp-IC}|w}{\partial w} = \frac{\lambda(1-\lambda)(\bar{\theta}-1)\Delta}{2t}, \quad \frac{\partial \pi_{eH}^{EO-comp-IC}|w}{\partial w} = \frac{\lambda[2t-(1-\lambda)(\bar{\theta}-1)\Delta]}{2t}.$$

When $w < w^{DD}$, $\frac{\partial \pi_k^{EO-comp-IC}|w}{\partial w} > 0$ for both firms (given the restrictions on t for a competitive outcome). However, if $w > w^{DD}$, the $[DD_{\theta}]$ conditions are violated. In this case, firms become *de facto* local monopolists. Thus, we use the results from §B.1 above and conclude the following with respect to $w > w^{DD}$:

For the incumbent, $\frac{\partial \pi_{iL}^{EO-mono-IC}|w}{\partial w} \leq 0$. This means that profits for the incumbent become decreasing in w . Consequently, the maximum profit for the incumbent occurs exactly at $w = w^{DD}$.

For the entrant, the interior optimal price is w^{FOC_mono} computed above. Additionally, the entrant needs to provide to the incumbent an outcome that is at least as good as that it can make by going alone (the GFT constraint $\pi_{iL}^{EO_mono_IC} \geq \pi_{iL}^{E_comp}$). Therefore, we define w^{GFT_comp} to be the wholesale price such that $\pi_{iL}^{EO_mono_IC}|_{w^{GFT_comp}} = \pi_{iL}^{E_comp}$. By solving the equality for w^{GFT_comp} , we find that

$$w^{GFT_comp} = \bar{\theta}\Delta + \frac{v(2\bar{\theta}-\bar{\theta}\lambda-1+\lambda)}{\lambda} - \frac{\sqrt{(c_{eH}+3t-\Delta)^2+(\bar{\theta}-1)\{18v^2-2\lambda[\Delta(c_{eH}+3t-\Delta)+9\bar{\theta}v^2]+[\lambda\Delta(\bar{\theta}-1)]^2\}}}{3\lambda}.$$

Given the above, we conclude that if the incumbent is the Leader, it proposes to buy the product at a price $w^* = w^{DD}$ and a touching equilibrium in the cheap consumers segment will ensue. If the entrant is the Leader, it proposes to sell the OEM product at a price $w^* = \max\{w^{FOC_mono}, w^{GFT_comp}\}$ and an endogenous local monopolistic equilibrium will ensue.

We remark that, technically, there is a small range of wholesale prices in which firms may face a local monopolistic market in a segment and a competitive market in another segment. This possibility does not affect the insights above because, in this parametric scenario, the incentives for the firms are the same as those in the local monopolistic scenario.

Outcomes for entry only. For the entrant, the strategy of OEM only is strictly dominated by OEM combined with entry, because, the firm can always increase profit by entering the market and selling to those consumers who locally prefer its brand.

The incumbent drops its own product. Similar to the preceding case, the incumbent always has an incentive to target the consumers who locally prefer its own brand with two different products; thus, the strategy of dropping its own product is strictly dominated by OEM combined with entry.

Analysis of the first stage

Given the outcomes above, the entrant's optimal strategy is to enter the market and also to OEM its product to the incumbent. In this outcome, both firms have an incentive to agree on a high wholesale price. A price that is at (when the incumbent is the Leader) or above (when the entrant is the Leader) the maximum price that respects the Differentiated Demand conditions. ■

C Proof of proposition 3

We prove that the entrant's entry strategy depends on the cost of the high-quality product.

First, notice that when the incumbent is alone in the market, it can produce both products and earn profit of $\pi_i^N = \lambda[v + \bar{\theta}\Delta - c_{iH}] + (1 - \lambda)v$. Also notice, in the claim below, that the entrant will not enter the market with the low-quality product.

Claim 1 *The entrant will not enter the market with the low-quality product.*

Proof. It is only profitable for the entrant to enter the market if it accrues positive profit. Thus, we only need to show that any price $p_e > 0$ for the low-quality product cannot be an equilibrium.

Suppose for a contradiction that the entrant is pricing the low-quality product at $\underline{p}_e = p > 0$, and that the incumbent is keeping the low-quality product out of the market and pricing the high-quality product at $\bar{p}_i = p + \bar{\theta}\Delta$ (so that it can capture choosy consumers). If that is the situation, the incumbent has an incentive to target all consumers by charging $\bar{p}_i = p + \bar{\theta}\Delta - \varepsilon$ and $\underline{p}_i = p - \varepsilon$. In other words, by reducing an infinitesimal amount of revenue from choosy consumers, the incumbent can capture all consumers. This move, however, encourages the entrant to undercut the incumbent by charging $\underline{p}_e = p - 2\varepsilon$. The logic repeats itself, until the low-quality product is priced at marginal cost ($p = 0$). Since the entrant cannot achieve positive profit by selling the low-quality product to consumers, it does not enter the market with this product. ■

With respect to the entrant's low-quality product, due to the reasoning in Claim 1, the entrant will not be able to enter the market with the low-quality product. In addition, because the entrant's threat of entering the market with the low-quality product is void, and because there is no positive wholesale price w_L for the low-quality product such that $\pi_i^O|w_L > \pi_i^N$, the entrant cannot forge an OEM relationship with the incumbent.

With respect to the entrant's high-quality product, the ensuing equilibrium depends on the firms' marginal cost of producing the high-quality product. If $c_{iH} < c_{eH}$, then we can use an argument similar to that in Claim 1 to argue that it is not profitable for the entrant to enter the market on its own. Furthermore, there is no wholesale price for the high-quality product $w_H > c_{eH}$ such that $\pi_i^O|w_H > \pi_i^N$, thus we rule out an OEM arrangement.

On the other hand, if $c_{iH} > c_{iL}$, the entrant can enter the market and earn profit. The entrant can price the high-quality product at $\bar{p}_e = c_{iH} - \varepsilon$ (see Blume 2003) and capture not only all choosy consumers, but also all cheap consumers, because $\Delta > c_{kH}$. However, if the entrant stays out of the market and OEMs the product to the entrant, then the incumbent can extract monopolistic revenues from consumers (i.e., charge $\bar{p}_i^O = v + \bar{\theta}\Delta$, $\underline{p}_i^O = v$). Consequently, there is a wholesale price w_H for the high-quality product such that $\pi_{iL}^O|w_H + \pi_{eH}^O|w_H \geq \pi_{iLH}^E + \pi_{eH}^E$.

Given the above, we write the OEM-only profit functions as:

$$\pi_{iL}^O|w_H = \lambda(v + \bar{\theta}\Delta - w_H) + (1 - \lambda)v, \quad \pi_{eH}^O|w_H = \lambda(w_H - c_{eH}).$$

Notice that $\frac{\partial \pi_{iL}^O|w_H}{\partial w_H} < 0$ and $\frac{\partial \pi_{eH}^O|w_H}{\partial w_H} > 0$. Therefore, if the incumbent is the Leader, it offers to buy the entrant's high-quality product at the lowest price w_H^* that respects the GFT constraint $\pi_{eH}^O|w_H \geq \pi_{eH}^E$. Conversely, if the entrant is the Leader, it offers to sell the OEM product at the highest price w_H^* that respects the GFT constraint $\pi_{iL}^O|w_H \geq \pi_{iLH}^E$. In both cases, the Follower accepts the contract. ■

D Proof of Proposition 4

D.1 Firms are local monopolists

In the local monopolistic equilibrium configurations, the solutions are straightforward because there is no competitive interaction. We remark first that, because firms do not compete for consumers, the entrant enters the market and both firms will be active in their respective captive markets.

With respect to the low-quality product, both firms are able to produce the low-quality product at cost $c_{iL} = 0$, it is logical to conclude that firms cannot agree on an OEM arrangement. Instead, each firm will produce that product on its own.

With respect to the high-quality product, firm k can produce the product on its own and accrue profit of $\pi_{kHL}^E = (\bar{p}_k - c_{kH})\lambda \left(\frac{\bar{\theta}(v+\Delta) - \bar{p}_k}{t} \right) + (\underline{p}_k) (1 - \lambda) \left(\frac{v - \underline{p}_k}{t} \right)$. Alternatively, firm k can source the product from firm $-k$ and accrue profit of $\pi_{kL}^{EO} = (\bar{p}_k - w)\lambda \left(\frac{\bar{\theta}(v+\Delta) - \bar{p}_k}{t} \right) + (\underline{p}_k) (1 - \lambda) \left(\frac{v - \underline{p}_k}{t} \right)$.

Without the need to solve the model, we know that any $w < c_{kH}$ is profitable for firm k , and that $\frac{\partial \pi_{kL}}{\partial w} < 0$. On the other hand, any $w > c_{-kH}$ is profitable for firm $-k$.

Thus, if $c_{kH} > c_{-kH}$, firms can reach an OEM arrangement in which firm k buys the high-quality product from the other firm. If firm k is the Leader, its profits are maximized by proposing to buy the OEM product at price $w^* = c_{-kH} + \varepsilon$. Conversely, if firm $-k$ is the Leader, its profit are maximized by proposing to sell the OEM product at price $w^* = c_{kH} - \varepsilon$. In both cases the Follower accepts the contract.

D.2 Firms can compete for consumers

Analysis of the third stage

First, notice in the claim below that if firms have the possibility of producing both product qualities, they cannot commit to selling less than two product qualities to consumers.

Claim 2 *Firms cannot commit to selling less than two product qualities to consumers.*

Proof. Consider that firm k has one of the products (either it is producing it or sourcing from the other firm). Because the firm is able to manufacture both products, and because in this equilibrium configuration there are consumers who locally prefer brand k (those consumers close to brand k 's location), the firm will always find it optimal to price-discriminate consumers and bring a second product to the market (either by producing it or sourcing it). Similarly, if firm k were selling no product to consumers, it would always find it better to produce or source a product to sell to those consumers who locally prefer its brand. ■

Because of the result in Claim 2, we can focus exclusively on outcomes in which firms are selling both product qualities to consumers. We investigate these outcomes below.

Both firms manufacture both products. In this case, both firms sell their own products to consumers; thus, the objective function for the firms is symmetric:

$$\pi_{kHL}^E = (\bar{p}_k - c_{kH})\lambda \left(\frac{1}{2} - \frac{(\bar{p}_k - \bar{p}_{-k})}{2t} \right) + (\underline{p}_k) (1 - \lambda) \left(\frac{1}{2} - \frac{(\underline{p}_k - \underline{p}_{-k})}{2t} \right).$$

The optimal solution to this problem yields outcomes of: $\pi_{kHL}^{E*} = \frac{t}{2} + \frac{\lambda[(c_{-kH} - c_{kH})^2 + 6t(c_{-kH} - c_{kH})]}{18t}$.

A firm does not manufacture products, the other manufactures two products. Suppose firm k does not manufacture a product and the other firm is manufacturing two products. By Claim 2, firm k buys both products from $-k$, thus the objective function for the firms are:

$$\begin{aligned}\pi_{k\emptyset}^{EO} &= (\bar{p}_k - w_H)\lambda \left(\frac{1}{2} - \frac{(\bar{p}_k - \bar{p}_{-k})}{2t} \right) + (\underline{p}_k - w_L)(1 - \lambda) \left(\frac{1}{2} - \frac{(\underline{p}_k - \underline{p}_{-k})}{2t} \right), \\ \pi_{-kHL}^{EO} &= (\bar{p}_{-k} - c_{eH})\lambda \left(\frac{1}{2} + \frac{(\bar{p}_k - \bar{p}_{-k})}{2t} \right) + (\underline{p}_{-k})(1 - \lambda) \left(\frac{1}{2} + \frac{(\underline{p}_k - \underline{p}_{-k})}{2t} \right) \\ &\quad + (w_H - c_{eH})\lambda \left(\frac{1}{2} - \frac{(\bar{p}_k - \bar{p}_{-k})}{2t} \right) + w_L(1 - \lambda) \left(\frac{1}{2} - \frac{(\underline{p}_k - \underline{p}_{-k})}{2t} \right).\end{aligned}$$

The optimal profits for the firms, conditional on w_H , and w_L , are:

$$\pi_{k\emptyset}^{EO*}|w_H, w_L = \frac{t}{2}, \quad \pi_{-kHL}^{EO*}|w_H, w_L = \frac{t}{2} + \lambda(w_H - c_{eH}) + (1 - \lambda)w_L.$$

A firm manufactures one product, the other manufactures two products. Suppose firm $-k$ is manufacturing just one product and the other firm is manufacturing two products. By Claim 2, firm k buys the product it does not manufacture from $-k$.

If firm k produces the low-quality product and sources the high-quality product from firm $-k$, the objective function for the firms are:

$$\begin{aligned}\pi_{kL}^{EO} &= (\bar{p}_k - w_H)\lambda \left(\frac{1}{2} - \frac{(\bar{p}_k - \bar{p}_{-k})}{2t} \right) + (\underline{p}_k)(1 - \lambda) \left(\frac{1}{2} - \frac{(\underline{p}_k - \underline{p}_{-k})}{2t} \right), \\ \pi_{-kLH}^{EO} &= (\bar{p}_{-k} - c_{eH})\lambda \left(\frac{1}{2} + \frac{(\bar{p}_k - \bar{p}_{-k})}{2t} \right) + (\underline{p}_{-k})(1 - \lambda) \left(\frac{1}{2} + \frac{(\underline{p}_k - \underline{p}_{-k})}{2t} \right) + w_H(1 - \lambda) \left(\frac{1}{2} - \frac{(\bar{p}_k - \bar{p}_{-k})}{2t} \right).\end{aligned}$$

The optimal profits for the firms, conditional on w_H , are:

$$\pi_{kL}^{EO}|w_H = \frac{t}{2}, \quad \pi_{-kLH}^{EO}|w_H = \frac{t}{2} + \lambda(w_H - c_{eH}).$$

If firm k produces the high-quality product and sources the high-quality product from firm $-k$, the objective function for the firms are:

$$\begin{aligned}\pi_{kH}^{EO} &= (\bar{p}_k - c_{iH})\lambda \left(\frac{1}{2} - \frac{(\bar{p}_k - \bar{p}_{-k})}{2t} \right) + (\underline{p}_{-k} - w_{eL})(1 - \lambda) \left(\frac{1}{2} - \frac{(\underline{p}_k - \underline{p}_{-k})}{2t} \right), \\ \pi_{-kLH}^{EO} &= (\bar{p}_{-k} - c_{eH})\lambda \left(\frac{1}{2} + \frac{(\bar{p}_k - \bar{p}_{-k})}{2t} \right) + \underline{p}_{-k}(1 - \lambda) \left(\frac{1}{2} + \frac{(\underline{p}_k - \underline{p}_{-k})}{2t} \right) + (w_{eL})(1 - \lambda) \left(\frac{1}{2} - \frac{(\underline{p}_k - \underline{p}_{-k})}{2t} \right).\end{aligned}$$

The optimal profits for the firms, conditional on w_L , are:

$$\pi_{kH}^{EO}|w_L = \frac{t}{2} + \frac{\lambda[(c_{-kH} - c_{kH})^2 + 6t(c_{-kH} - c_{kH})]}{18t}, \quad \pi_{-kLH}^{EO}|w_L = \frac{t}{2} + (1 - \lambda)w_L + \frac{\lambda[(c_{-kH} - c_{kH})^2 - 6t(c_{-kH} - c_{kH})]}{18t}.$$

Firms produce one differentiated product each. Lastly, we compute the outcomes when firms produce vertically-differentiated products and act as suppliers to each other.

When firm k supplies the high-quality product and firm $-k$ the low-quality product, the objective functions for the firms are:

$$\begin{aligned}\pi_{kH}^{EOO} &= (\bar{p}_k - c_{kH})\lambda \left(\frac{1}{2} - \frac{(\bar{p}_k - \bar{p}_{-k})}{2t} \right) + (\underline{p}_k - w_L)(1 - \lambda) \left(\frac{1}{2} - \frac{(\underline{p}_k - \underline{p}_{-k})}{2t} \right) + w_H\lambda \left(\frac{1}{2} + \frac{(\bar{p}_k - \bar{p}_{-k})}{2t} \right), \\ \pi_{-kL}^{EOO} &= (\bar{p}_{-k} - w_H)\lambda \left(\frac{1}{2} + \frac{(\bar{p}_k - \bar{p}_{-k})}{2t} \right) + (\underline{p}_{-k})(1 - \lambda) \left(\frac{1}{2} + \frac{(\underline{p}_k - \underline{p}_{-k})}{2t} \right) + w_L(1 - \lambda) \left(\frac{1}{2} - \frac{(\underline{p}_k - \underline{p}_{-k})}{2t} \right).\end{aligned}$$

By taking derivatives and simultaneously solving for the first order conditions, we find the optimal prices for the firms: $\underline{p}_k^{EOO*} = t + w_L$, and $\bar{p}_k^{EOO*} = t + w_H$.

The optimal profits for the firms, conditional on w_H , and w_L , thus are:

$$\pi_{kH}^{EOO*}|w_H, w_L = \frac{t}{2} + \lambda(w_H - c_{iH}), \quad \pi_{-kL}^{EOO*}|w_H, w_L = \frac{t}{2} + (1 - \lambda)w_L.$$

Notice that $\pi_{kH}^{EOO*}|w_H, w_L$ is independent of w_L and it is strictly increasing with w_H . Hence, firm k will prefer high wholesale prices for the high-quality product that respect the $[DD_\theta]$ conditions, which in this case is set by the upperbound limit $w_H^{DD} = \bar{\theta}(v + \Delta) - \frac{3t}{2}$.

Similarly, $\pi_{-kL}^{EOO*}|w_H, w_L$ is independent of w_H and strictly increasing on w_L . Hence, firm $-k$ will prefer high wholesale prices for the low-quality product that respect the $[DD\theta]$ conditions, which in this case is set by the upperbound limit $w_L^{DD} = v - \frac{3t}{2}$.

Analysis of the initial stages

With the calculations above, we can investigate the outcomes in the first and second stages.

Notice that $\pi_{iH}^{EOO*}|w_H, w_L > \pi_{iL}^{EO}|w_H = \pi_{i\emptyset}^{EO*}$ and that $\pi_{iL}^{EOO*}|w_H, w_L > \pi_{iL}^{EO*}|w_H = \pi_{i\emptyset}^{EO*}$ for all values of w_H and w_L , thus we can rule out an equilibrium in which the incumbent buys both products from the incumbent and also an equilibrium in which the incumbent produces the low-quality product and sources the high-quality product from the entrant (without selling the low-quality product to the entrant). Also notice that $\pi_{iH}^{EO*}|w_L = \pi_{iHL}^{E*}$. Therefore, we only need to compare $\pi_{iH}^{EOO*}|w_H, w_L$ and $\pi_{iL}^{EOO*}|w_H, w_L$ with π_{iHL}^{E*} to find the dominating outcome.

By solving $\pi_{iH}^{EOO*}|w_H, w_L = \pi_{iHL}^{E*}$ for w_H and w_L , we find that $w_H^{Indif} = \frac{(c_{eH}-c_{iH})^2+6t(c_{eH}+2c_{iH})}{18t}$, while any w_L satisfies the equality. Similarly, by solving $\pi_{iL}^{EOO*}|w_H, w_L = \pi_{iHL}^{E*}$ for w_H and w_L , we find that any w_H satisfies the equality, and that $w_L^{Indif} = \frac{\lambda}{1-\lambda} \frac{(c_{eH}-c_{iH})^2+6t(c_{eH}-c_{iH})}{18t}$.

Hence whenever the firm producing the high-quality product gets an OEM price w_H^* such that $w_H^{Indif} \leq w_H^* \leq w_H^{DD}$, and the firm producing the low-quality product gets a price w_L^* such that $w_L^{Indif} \leq w_L^* \leq w_L^{DD}$, they will prefer to supply to each other instead of any other option. Notice that w_L^{Indif} increases fast with λ and at first glance, one may think that w_L^{Indif} can be greater than w_L^{DD} . This fact, however, only implies that for large values of λ , the equilibrium requires that the firm with the smaller marginal cost for the high-quality product is the one supplying the high-quality product. This guarantees that not only $w_L^{Indif} < w_L^{DD}$, but also $w_H^{Indif} < w_H^{DD}$ for all admissible values of the parameters.

Lastly, we check the $[IC\theta]$ conditions. Suppose the firm producing the high-quality product is the Leader. The firm would like to sell its product at a price which is as high as possible, which is $w_H = w_H^{DD}$. However, this is not possible, because such a price would violate $[IC\bar{\theta}]$. To be able to set the highest constrained price, the leader would propose to buy the low-quality product at the maximum possible price ($w_L^* = w_L^{DD} = v - \frac{3t}{2}$) and to sell the high-quality product at the maximum price that respects $[IC\bar{\theta}]$. More specifically, $w_H^* = w_L^* + \bar{\theta}\Delta = v + \bar{\theta}\Delta - \frac{3t}{2}$.

Next suppose the firm producing the low-quality product is the Leader. The firm would like to sell its product at the highest possible price, which is $w_L^* = w_L^{DD} = v - \frac{3t}{2}$. To be able to price the low-quality product that high, the firm needs to buy the high-quality product at a price that prevents consumer price distortions. Therefore, the Leader needs to buy the high-quality product at a price w_H such that $\underline{p}_k^{EOO*} + \Delta \leq \bar{p}_k^{EOO*}$ and $\underline{p}_k^{EOO*} + \bar{\theta}\Delta \geq \bar{p}_k^{EOO*}$, which implies that $w_H^* \in [v + \Delta - \frac{3t}{2}, v + \bar{\theta}\Delta - \frac{3t}{2}]$. This means that regardless of which firm is the Leader, the ensuing equilibrium is always a *touching equilibrium* in the cheap consumers segment. ■