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

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We investigate the optimal market entry and original equipment manufacturer (OEM) decisions of a firm facing a market in which firms' brands can be horizontally differentiated and products can be vertically differentiated. The entrant might sell under its own brand and compete with an incumbent, become a supplier to the incumbent, or both. Findings reveal that when consumers perceive the firms are horizontally and vertically differentiated, the entrant profits by simultaneously entering the market and establishing an OEM arrangement with the incumbent. In such competitive scenarios, both buyer and seller increase profits by agreeing on wholesale prices that are not too low, which softens both horizontal and vertical conflict between the firms. Findings also show that the incumbent may prefer to pay high wholesale prices to the entrant even if the incumbent had the option to source the product independently at a lower marginal cost. When firms have the capability of producing each other's product lines, supply relationships between them can still happen in equilibrium. In this case, an interesting result is that firms may optimally select to differentiate production and, because of the OEM relationship, sell the same product qualities to consumers. The reason for this outcome is that the OEM arrangement with differentiated production causes a strategic effect that reduces the firms' aggressiveness when competing for consumers. Under certain conditions, the OEM arrangement can completely nullify the horizontal and vertical conflict between the firms.

Keywords: channel cooperation; competitive strategy; distribution; industrial marketing; market entry; price discrimination
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1. Introduction

In the modern business environment, it is becoming increasingly common for firms not only to sell products to consumers under their own brand but also establish distribution agreements in which one firm sells goods or intellectual property to another firm, to be sold to end consumers under the latter's brand. Original equipment manufacturer (OEM) agreements, private-label supplying agreements, and some forms of licensing are examples of this practice.

Common wisdom suggests that such channel arrangements are likely to be profitable for the firms when there is limited to no competition for consumers. In such situations, the dual-channel relationship with rebranding can be an opportunity for the supplier to create demand that better utilizes the firms' production capacity and reach consumers that the firm would not otherwise have access to. For the reseller firms, these arrangements can be an opportunity to complement their product lines and appropriate more of the total profit on the channel (Kumar and Steenkamp 2007).

However, when firms compete for consumers, the literature notes that dual-channel arrangements may lead to channel conflict between the supplier and the reseller (Chiang et al. 2003, Coughlan et al. 2001). A strong source of conflict that may emerge is horizontal conflict because channel partners may end up competing for end consumers. Another strong source is vertical conflict because, in general, suppliers desire high wholesale prices, whereas resellers desire low wholesale prices. Nevertheless, firms do exercise this more complex option of adopting dual channels with rebranding in situations in which they compete for consumers. Real-world examples include Pentax selling its digital single-lens reflex cameras to consumers and to Samsung, which resells them under its own brand (Richards 2006); Canon selling wide-format printers to end customers and also to Océ, which rebadges the products and resells them to business customers (*Printing World* 2006); and Heinz selling ketchup to consumers and as a private-label supplier to retail chains (Kumar and Steenkamp 2007).

In this paper, we provide a rationale for the implementation of dual channels with rebranding even when firms compete for consumers. We show that such channel arrangements may actually *reduce* the vertical and horizontal conflict between the firms.

In fact, the reduction of conflict may be a reason for firms to engage in the relationship, and may be a desirable outcome for both of them. We show that this can be true even if both firms have the possibility of producing (or sourcing) the product on their own.

Our explanation comes from a game-theory model that examines a potential entrant's[1] outcomes with respect to its channel choices. For conciseness, we adopt the context of an entrant manufacturer considering entry and/or an OEM supply relationship with an incumbent manufacturer (with the understanding that other forms of supply with rebranding can fit the scope of our research). Firms may have different brand images, creating horizontal differentiation, and different product qualities, creating vertically differentiated product lines. By the same token, consumers may have heterogeneous preferences for brand and product qualities.

Our analysis shows that if firms are horizontally differentiated but still compete for consumers, then it is optimal for the entrant to enter the market and sell its product to end consumers using its own brand and also to establish an OEM arrangement with the incumbent. In this particular situation, not only the entrant (the seller) but also the incumbent (the buyer) benefits by contracting on wholesale prices that are not too low, which reduces the vertical and horizontal conflict that typically happens in dual-channel relationships. Results also show that even if the incumbent could source the product on its own with low marginal costs, it would nevertheless prefer the OEM agreement with the entrant and pay higher wholesale prices.

An extension to the model that allows firms to endogenously select their product lines and become suppliers to each other shows that firms will optimally choose to differentiate production and engage in an OEM relationship so they can offer products of the same vertical qualities to end consumers. This occurs because the differentiation in product production in conjunction with the OEM supply arrangement softens the horizontal conflict (competition) that would otherwise emerge if firms were independently producing and offering goods of the same quality to the market. Furthermore, the production and OEM supply arrangement also softens the vertical conflict between the firms. In fact, under certain conditions, the vertical conflict between firms is completely eliminated. It deserves notice that this outcome is more efficient than the traditional "maximum differentiation" outcome because it mitigates conflict while better accommodating consumer preferences.

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 firms are horizontally differentiated and compete for consumers, focusing first on situations in which firms' product lines are exogenous, and then on situations in which one of the firms can find an alternative source for the product. Section 4 extends the model by considering the possibility of multiproduct manufacturing and endogenous product-line choices. These two sections present the core findings of our research about firms' strategy and reduction of channel conflict. Section 5 discusses the effect of homogeneity in consumers' horizontal and vertical preferences in regulating the firms' optimal strategies and channel conflict. The paper concludes in §6 by summarizing the results, presenting managerial implications, and discussing research limitations and possible future extensions.

1.1. Literature Review

Channel conflict received much attention in the marketing literature. Early work demonstrates the existence of vertical conflict when firms engage in bilateral vertical relationships (Jeuland and Shugan 1983, Moorthy 1987) and the existence of horizontal conflict when members of the same or different channels compete with each other (Ingene and Parry 1995, McGuire and Staelin 1983). In these early contributions, the conflict stems from channel members' disagreements over the consumer prices (or wholesale prices) of products and the sharing of channel profits. Subsequent literature establishes that channel members may disagree on a variety of other issues. For instance, they may have disagreements about the quality of products offered to consumers (Villas-Boas 1998), the allocation of sales force incentives to promote products (Caldieraro and Coughlan 2007), and the costing and salvaging responsibility of consumer product returns (Shulman et al. 2010). Our study focuses on the reduction of (potential) horizontal and vertical conflict in dual channels with rebranding via the formation of OEM supply relationships.

The literature in dual channels is also well established. Some of the main topics covered in this literature are the trade-offs between channel integration and decentralization (Trivedi 1998), channel coordination (Chiang et al. 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 (Arya et al. 2005, Bernstein et al. 2008, Choi 2003, Kumar and Ruan 2006) and on the provision of other marketing mix elements such as price, service, and incentives (Rubel and Zaccour 2007, Tsay and Agrawal 2004, Zhang 2009). Related work by Liu

[1] The 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.

and Zhang (2006) focuses on the decisions of a retailer who can target promotions to discourage a partner manufacturer from implementing a direct channel.

The rebranding aspect of our model relates to the literature in private labels. Much of the analytical work in this area focuses on the retailer's decision to introduce a private-label brand (Chan Choi and Coughlan 2006, Raju et al. 1995, Sayman et al. 2002). Research that focuses on the suppliers' decision includes Wu and Wang (2005), which considers manufacturers supplying through a common retailer and shows that offering a private label can mitigate promotion competition between national brands, and Nasser et al. (2013), which studies the optimal competitive response of a national brand manufacturer to the retailer's introduction of its own private label. Our paper adds to the literature by investigating an entrant (supplier) strategy that can sell directly to consumers, with a focus on the conditions in which the supply relationship between companies and the implementation of higher wholesale prices can *soften* the potential horizontal and vertical conflict between channel partners. A structural empirical investigation of private-label supply relationships is Chen et al. (2010). The study finds, as we do, that a national-brand supplier can benefit by adding a private-label line because adding the line increases sales volume; the research also examines the impact of vertical integration on product prices and finds that wholesale and retail prices of a product are higher in a non-vertically integrated channel, a result that is in line with double marginalization. In our model, the softening in competition and potential conflict are important drivers of the strategy of entering the market and supplying the product to a competitor. This reduction in conflict may even lead a buying firm to prefer paying high wholesale prices to a competitor even if the buyer could source products on its own at lower marginal costs.

There exists literature on licensing between competing firms that connects with 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) investigate fixed-fee licensing of cost-reducing technological advances by Cournot competitors and conclude that major advances will not be licensed. Subsequent research investigates the possibility of both a fixed-fee and a royalty (per-unity) fee in oligopolistic Cournot and Bertrand competitive markets (Rockett 1990; Kamien et al. 1992; Wang 1998, 2002). These papers identify conditions under which firms may prefer a fixed-fee or a royalty contract. Other studies focus on the impact of additions to the standard licensing contracts and compare the results with those of previous research. Lin and Kulatilaka (2006) investigate hybrid fixed-fee and royalty contracts, Li and Yanagawa (2011) consider a Stackelberg manufacturer that can offer two-part tariff licensing, and Xiao and Xu (2012) consider the possibility of contract renegotiation. None of these papers investigates how heterogeneity in consumer horizontal and vertical tastes regulates firms' incentives to enter a market and/or supply their products to competitors or considers the possibility of reciprocal supply arrangements as we do.

Other related research includes 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 et al. (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 et al. (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. Another related paper by Ishibashi and Matsushima (2009) finds that high-end firms may benefit from the existence of low-end firms because it decreases the attractiveness of competing for less-profitable consumers. 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. They also do not explain how high wholesale prices may act as a commitment device to soften competition, that benefits both the buyer and the seller and also both low- and high-quality firms.

2. Model Setup

As presented in the introduction, we are interested in supply arrangements with rebranding, involving a manufacturer who possesses a product and has to decide whether to enter the market and/or sell the product to a reseller who also produces or sources a substitute product. This type of situation can be exemplified by an OEM supply arrangement between two manufacturing companies, a private-label supply arrangement between a manufacturer and a retailer, or a licensing agreement in which a manufacturer licenses a product to another manufacturer and charges a per-unity royalty fee. For simplicity of exposition, we will adopt the OEM interpretation.

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.[2] In the first stage, the entrant chooses whether or not to enter the market and whether or not to establish an OEM supply arrangement with the incumbent. In the second stage, firms set prices to end consumers.

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 $c_{kH} > 0$. We use the index $q \in \{L, H\}$ to reference quality. 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 consumer 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), with the consideration that if a firm is indifferent between two or more outcomes, we allow the outcome to accommodate the other firm's preferences.[3] We further assume that either entering the market or establishing an OEM contract requires an infinitesimally small cost, so 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 (for similar models, see Desai 2001, Kim et al. 2001, Villas-Boas 1998). Vertical differentiation arises from differences in product quality and in consumers' valuation of product quality. For simplicity, it is assumed that there are two types of consumers represented by a taste for quality parameter $\theta \in \{\bar{\theta}, \underline{\theta}\}$ with $\bar{\theta} > \underline{\theta} = 1$. The parameter not only captures a consumer type but also expresses differences in consumer valuations: consumers $\bar{\theta}$ are *high-type* consumers who have high valuation for quality, and $\underline{\theta}$ are *low-type* consumers who have low valuation for quality. The probability of a consumer being type $\bar{\theta}$ is $\text{Prob}(\bar{\theta}) = \lambda_{\bar{\theta}} = \lambda$ with $\lambda \in (0, 1)$ and consequently $\text{Prob}(\underline{\theta}) = \lambda_{\underline{\theta}} = 1 - \lambda$. It is assumed that firms know the proportions of consumers, but that the type of a consumer is private information.

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, and $\Delta > c_{kH}$ (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.

To capture horizontal differentiation, we consider that consumers in the market have different preferences for the firms' brand images.[4] These preferences are uniformly distributed on a Hotelling market with size one. The consumer whose ideal brand image is located at x and who consumes a product from a firm located at x^0 derives utility $u = V(\theta, q) - p - t|x^0 - x|$, where t is a "transportation cost" parameter, which represents the disutility from purchasing a product that does not match her brand 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.

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 differentiated when $t > 0$, and horizontally undifferentiated when $t = 0$. This is a well-known method of capturing differentiation (Tirole 1988, Chen and Iyer 2002). Because the objective of this research is to study strategic interactions, our main attention will be dedicated to scenarios in which firms can successfully compete for at least some of the consumers.

In the first part of the analysis, we focus on situations in which firms' product qualities are exogenous. This captures real-world situations in which the entrant has limited capacity to adjust product quality. Subsequently, we extend the model by allowing firms to manufacture both product qualities and to choose product lines endogenously.

The timing of the game is as follows: In the first stage, the entrant decides its own action (no entry, OEM supply only, entry only, or entry combined with OEM supply). 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 Stackelberg 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.

The game is solved by applying the principle of sequential rationality and finding the subgame perfect Nash equilibrium (SPNE). 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). Next, for the situations in which firms can reach an OEM supply agreement, we determine the optimal wholesale price (interim

[2] For 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.

[3] The impact of more complex contracts such as two-part tariffs will be discussed in §6.

[4] As 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. We notice that other firm characteristics, such as location, clientele, and service, may have the same qualitative meaning as brand image differentiation (see, for instance, Dukes et al. 2006).

stage), according to a Stackelberg process. Finally, we determine the optimal entrant's decision in the first stage, by taking into account anticipated profits for each possible decision.

3. Model Analysis

Before analyzing the possible outcomes that may emerge from this model, the following considerations are established. First, firm k's demand from a segment of consumers constitutes all consumers of the same type who obtain positive utility and get more utility from firm k's product than from the other firm. Since $u_{\theta k} = V(\theta, q) - p - t|x^0 - x|$, 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 the consumer located at $x^*_{\theta k} = \frac{1}{2} + \{[V(\theta, q_k) - V(\theta, q_{-k})] - (p_k - p_{-k})\}/(2t)$ is indifferent between both firms. Therefore, demand for the incumbent and the entrant from a given segment θ is given by the Hotelling competitive demand:

$$D_{\theta k} = \frac{1}{2} + \frac{[V(\theta, q_k) - V(\theta, q_{-k})] - (p_k - p_{-k})}{2t}. \quad (1)$$

This expression is true, provided the following *differentiated demand* condition is satisfied for both high-type and low-type consumers:

$$[DD_\theta]\colon [V(\theta, q_i) - p_i] + [V(\theta, q_e) - p_e] > t. \quad (2)$$

This condition guarantees that all consumers in the segment get a positive utility and the segment θ will be fully covered. If the $[DD_\theta]$ condition is not satisfied, demand from a segment of consumers is determined by finding the indifference point x_θ such that $u_{\theta k} = 0$. The solution to this equation gives the Hotelling monopolistic demand:

$$D_{\theta k} = \frac{V(\theta, q_k) - p_k}{t}. \quad (3)$$

Second, given our assumptions on the value function parameters, a firm that has two products can extract more value from consumers by charging a (higher) price $\bar{p}$ for a high-quality product and a (lower) price $\underline{p}$ for a low-quality product (see Varian 1989 for a discussion). Hence, the following *incentive compatibility* conditions should be observed: $\bar{\theta}(v + \Delta) - \bar{p} \geq \bar{\theta}v - \underline{p}$, and $v + \Delta - \bar{p} \leq v - \underline{p}$. These conditions guarantee that consumers in a segment will prefer to buy the product directed to them. The conditions can be simplified as

$$[IC_{\bar{\theta}k}]\colon \bar{p} \leq \underline{p} + \bar{\theta}\Delta, \quad [IC_{\underline{\theta}k}]\colon \bar{p} \geq \underline{p} + \Delta. \quad (4)$$

With these determinations, we carry forward the model analysis.

3.1. Differentiated Firms with Exogenous Product Lines

In this section, we focus on environments in which firms can compete for consumers but are horizontally differentiated enough that they enjoy some degree of market power over consumers who strongly prefer their respective brands. This requires observing some regularity conditions on the magnitude of the transportation cost parameter t relative to the other parameters. On the one hand, we consider that firms are sufficiently differentiated so that there is a pure strategy equilibrium in the pricing subgame. This requires $t > [(3\theta - 2)\Delta - |c_i - c_e|]/3$. On the other hand, we also consider that differentiation is not so high that firms become local monopolists in a consumer segment. This requires $t < (2v + \Delta - c_i - c_e)/3$. Firms are also vertically differentiated with exogenous product lines.

The analysis proceeds by first investigating equilibrium outcomes in the second stage 2 and then determining the optimal strategy for the entrant in the first stage. The full derivations are in Appendix A.

3.1.1. Entry-Only Outcomes: Scenario (*E*). Consider first the outcomes if the entrant enters the market independently (we use the superscript E to denote this strategy). Since firms only have one product[5] to be directed to both segments, profits for the firms are given by $\pi^E_k = (p^E_k - c_k)[\lambda D^E_{\bar{\theta}k} + (1 - \lambda)D^E_{\underline{\theta}k}]$.

By solving for the equilibrium prices, we find that optimal profit outcomes for the firms are

$$\pi^{E*}_k = \frac{1}{18t} \cdot \{3t - c_k + c_{-k} + \lambda[V(\bar{\theta}, q_k) - V(\bar{\theta}, q_{-k})] + (1 - \lambda)[V(\underline{\theta}, q_k) - V(\underline{\theta}, q_{-k})]\}^2. \quad (5)$$

Since $\pi^{E*}_k > 0$ for both firms, it is clear that the entrant does better by entering the market than by staying out of the market.

3.1.2. Entry Conjugated with an OEM Supply Arrangement: Scenario (*ES*). Next, one considers whether it will be profitable for the entrant to not only enter the market but also sell the product to the incumbent in an OEM supply arrangement (we use the superscript ES to denote this strategy). Below, we discuss the outcomes for the case in which the incumbent produces a high-quality product and the entrant produces a low-quality product. The analysis for the reverse situation produces similar qualitative results.

If the OEM supply arrangement is established, the incumbent has the opportunity to screen consumers by charging a (lower) price $\underline{p}^{ES}_i$ for the low-quality

[5] Firms have one product because of the exogenous product line assumption. This assumption will be relaxed in §4.

product and a (higher) price $\bar{p}_i^{ES}$ for the high-quality product; then the incumbent's profit expression is

$$\pi_{iH}^{ES} = (\bar{p}_i^{ES} - c_{iH})\lambda D_{\bar{\theta}i}^{ES} + (\underline{p}_i^{ES} - w)(1-\lambda)D_{\underline{\theta}i}^{ES}.$$

The entrant has one product and targets both segments with it; hence its profit from consumers is $p_e^{ES}[\lambda D_{\bar{\theta}e}^{ES} + (1-\lambda)D_{\underline{\theta}e}^{ES}]$. The entrant also earns profit of $w(1-\lambda)D_{\bar{\theta}i}$ from selling the OEM product to the incumbent. Thus, the entrant's overall profit is

$$\pi_{eL}^{ES} = p_e^{ES}[\lambda D_{\bar{\theta}e}^{ES} + (1-\lambda)D_{\underline{\theta}e}^{ES}] + w(1-\lambda)D_{\underline{\theta}i}^{ES}.$$

Appendix A shows that the final prices to consumers are dependent on the wholesale price w and that there is a threshold wholesale price w^{DD}, that causes firms to switch to a different equilibrium regime in the pricing subgame—we follow Economides (1984) to label regimes.

For low values of w ($w < w^{DD}$), the optimal prices for the firms are low enough that all consumers are being served by a firm (both segments are fully covered). In this *competitive equilibrium* regime, profits for the incumbent and the entrant are increasing with w (i.e., $\partial(\pi_k^{ES} \mid w)/\partial w > 0$).

If w increases ($w > w^{DD}$), the market configuration in the low-type consumer segments transitions to a *touching equilibrium* in which the low-type consumer segment is barely covered.[6] In this regime, profit for the incumbent decreases with w (i.e., $\partial(\pi_{iL}^{ES} \mid w)/\partial w < 0$), whereas profit for the entrant has an interior maximum that we denote as w^{FOC}.

To fully characterize the ensuing equilibrium in this strategy, an additional consideration needs to be made: when a firm proposes a vertical arrangement to the other firm, the outcomes in the arrangement need to be at least as good as the one the firm could get by not taking the contract, which is given by the outcomes in the entry-only strategy π_k^{E*}. Otherwise, the proposal will be rejected. We call this the *gains-from-trade* constraint that

$$[GT_k]\text{: } \pi_k^{ES} \mid w \geq \pi_k^{E*}. \tag{6}$$

Given the above, we now characterize the equilibrium outcome in scenario *ES*. Because profit for the incumbent is increasing for $w < w^{DD}$ and decreasing when $w > w^{DD}$, if the incumbent is the Stackelberg leader, it proposes to buy the product at a price $w_i^* = w^{DD}$. This price automatically satisfies $[GT_e]$ because when $w < w^{DD}$ profits are increasing in w for both firms. On the other hand, because the optimal profit for the entrant has an interior maximum that occurs at a $w^{FOC} > w^{DD}$, we conclude that the entrant would desire to set the wholesale price at w^{FOC}. However, since profit for the incumbent decreases for values above w^{DD}, the constraint $[GT_i]$ may be binding. Consequently, if the entrant is the Stackelberg leader, it proposes to sell the OEM product at a price $w_e^* = \max\{w^{FOC}, w^{GT}\}$, where w^{GT} satisfies the $[GT_i]$ constraint with equality.

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 serve 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.

This analysis allows us to formalize the optimal strategy for the entrant in the first stage of the game. This is done in the proposition below.

Proposition 1. *When firms are differentiated with exogenous product lines, the entrant will pursue the dual strategy of entering the market and also supplying its product to the incumbent. In this arrangement, both firms have an incentive to agree on wholesale prices that are not too low, which softens both horizontal and vertical conflict between them.*

Proof. See Appendix A. □

Proposition 1 establishes that the entrant prefers to enter the market both directly and through a mutually agreeable OEM supply contract, which reduces horizontal conflict (competition) between firms that would otherwise occur. It also establishes that both the buyer and the seller desire a wholesale price that is not so low, which implies that the price of the wholesale product is not a big source of conflict as it normally is in vertical contracts. This qualitative result is robust to whether the entrant or the incumbent is the Stackelberg leader.

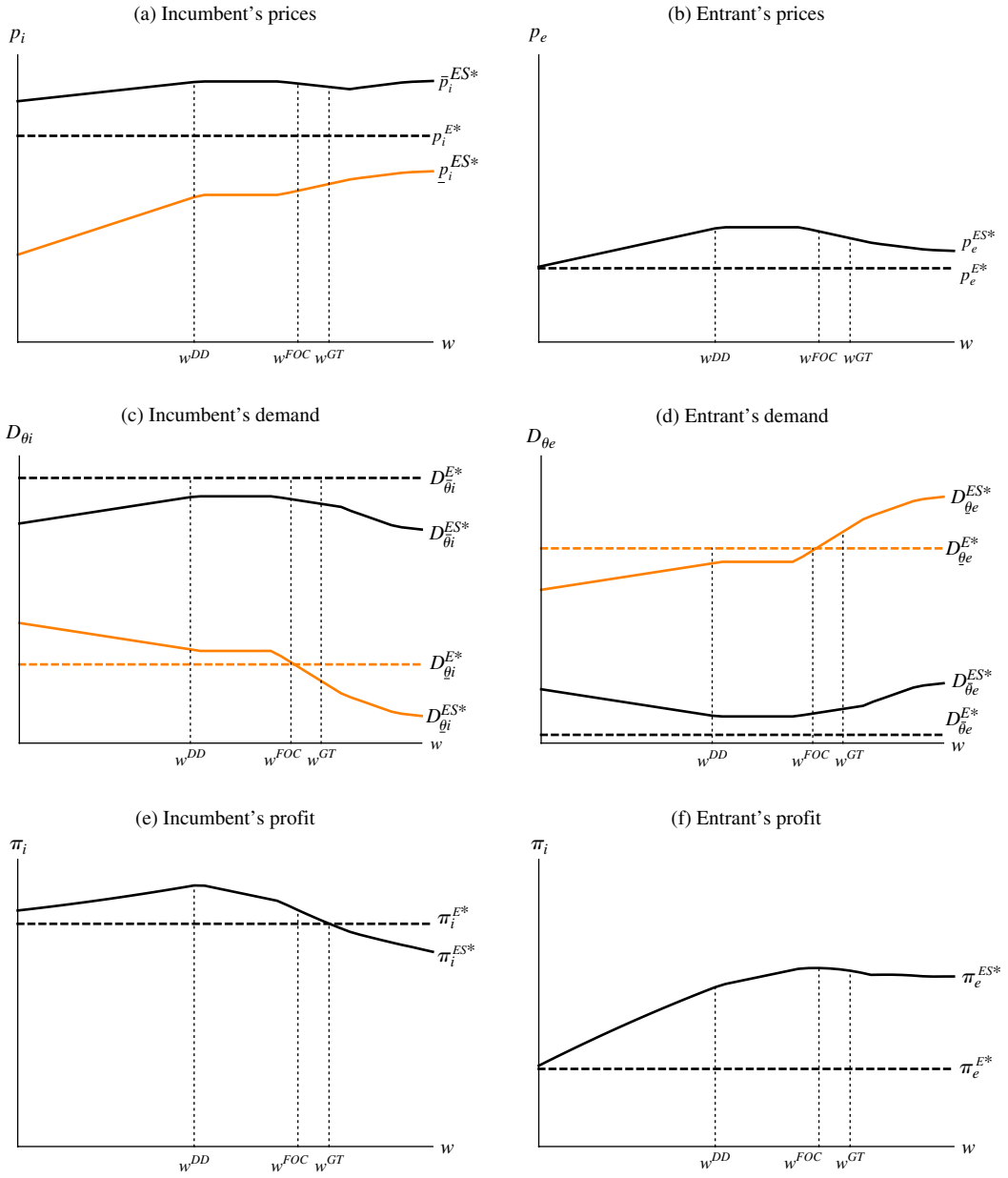
To better understand the result, consider Figure 1. The figure depicts the entry-only (*E*) and entry-and-OEM-supply (*ES*) outcomes as a function of the wholesale price w.

If firms go to market independently, they compete with one product each for the two consumer segments. The incumbent will sell mostly to high-type consumers, but it still wants to sell its product to some of the low-type consumers who strongly prefer its brand ($D_{\bar{\theta}i}^{E} > D_{\underline{\theta}i}^{E}$). By the same token, the entrant will sell mostly to low-type consumers but still wants to target some of the high-type consumers ($D_{\bar{\theta}e}^{E} < D_{\underline{\theta}e}^{E}$). The prices ($p_i^{E*}$ and p_e^{E*}) and profits (π_i^{E*} and π_e^{E*}) are depressed because of the competition between both firms (analogous to a strong horizontal conflict).

If an OEM supply arrangement is established, the incumbent sells its own product to high-type consumers for the price $\bar{p}_i^{ES}$ and the OEM product to low-type consumers at a price $\underline{p}_i^{ES}$ (activating a

[6] The appendix explains that the touching equilibrium configuration can admit more than a single value of w.

Figure 1 **(Color online) Optimal Prices, Demands, and Profits as a Function of the Wholesale Price *w***



surplus-extraction effect), whereas the entrant continues to have a single price for its product.

Consider what happens when $w < w^{DD}$. Because of the direct effect in marginal cost, an increase in w "forces the hand" of the incumbent, making it increase the price $\underline{p}_i^{ES}$. This increase enables the entrant to raise consumer prices p_e^{ES} because it relaxes competition in the low-type consumer segment. In turn, the increase in p_e^{ES} allows the incumbent to increase $\bar{p}_i^{ES}$. It is, therefore, the compounding effect of strategic complementarity of prices that drives this overall price-increasing effect: An increase in w causes an "across-the-board" increase in consumer prices that relaxes horizontal and vertical conflict and allows firms to accrue more profits.

If, however, w is so high that firms reach a touching equilibrium configuration ($w > w^{DD}$), the following happens: the entrant initially absorbs the cost of wholesale increases and prices are constant in w. Further increases in w make it optimal for the incumbent to ration out consumers by increasing $\underline{p}_i^{ES}$ and for the entrant to actually reduce p_e^{ES} to capture consumers that were rationed out by the incumbent. In sum, the price-increasing effect vanishes.

For the incumbent, this means that once $w \geq w^{DD}$, it starts experiencing decreasing profits as a direct

function of wholesale price. Thus, the incumbent prefers w to be exactly at w^{DD}. For the entrant, profits continue to increase with w because of the direct effect of higher revenues from the wholesale product up to the point in which $w = w^{FOC}$. At this point, the direct wholesale revenue effect is overpowered by the double marginalization effect, which could cause demand to decrease to suboptimal levels if prices were to be higher. Therefore, the entrant starts experiencing a decrease in profits if w were to increase above w^{FOC}. Notice that in the example depicted in Figure 1, $w^{FOC} < w^{GT}$, therefore the $[GT_k]$ constraint is slack, which enables both firms to keep some of the extra surplus (if parameters were such that $w^{FOC} > w^{GT}$, then a Stackelberg leader entrant would keep all of the extra surplus).

In conclusion, 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 noncooperatively according to their best interests, firms reach an equilibrium in which they accord with each other and establish an OEM agreement with a wholesale price that is not too low, even if they compete with each other when selling the product to consumers.

The aforementioned example of Canon selling wide-format printers to end consumers and also to Océ illustrates this scenario (*Printing World* 2006). Cannon and Océ have distinctive brands, with Cannon more known by individual consumers and Océ by business customers (thus the horizontal differentiation). Furthermore, Océ had a portfolio of high-capacity professional printers, whereas Cannon had a portfolio of consumer and home-office printers (thus the vertical differentiation). Even though both companies competed in the American and European markets, Océ was able to complement its line with an entry-level wide-format printer, and Cannon was able to penetrate the market of business customers who preferred to buy from Océ.[7]

3.2. The Incumbent Can Source the OEM Product Independently

One may wonder what would happen if the incumbent had the ability to source the OEM product on its own, without the need to buy it from the entrant. We label this case scenario *EI*.

Notice first that the incumbent is never worse off by having the possibility of sourcing independently. This is because the outcomes in scenario *EI* are never inferior to those in scenario *E*. This means that we need to rewrite the $[GT_k]$ constraint as

$$[GT_k^{EI}]\colon\ \pi_k^{ES} \mid w \geq \pi_k^{EI*}.$$

[7] The 2006 agreement between Océ and Cannon was indeed successful. Years later, Canon acquired Océ.

Using the results from the previous section, we realize that when the wholesale price is fixed to be the entrant's marginal cost ($w = c_e$), the outcomes in scenario *EI* are identical to those in scenario *ES*. The reason is that for the incumbent, the origin of the product does not affect the firm's objective function directly; for the entrant, the setting is equivalent to a situation in which the entrant is not supplying the product, since it receives a net revenue of zero. In addition, we know from the results in the previous section that the incumbent has higher profit when $w = w^{DD}$.

Following the rationale in the previous section, we conclude that if the incumbent is the Stackelberg leader, it decides not to source the product on its own and proposes to buy the OEM product at a price $w_i^* = w^{DD}$. By the same token, if the entrant is the Stackelberg leader, it proposes to sell the OEM product at a price $w_e^* = \max\{w^{FOC}, w^{GT\_EI}\}$, where w^{GT_EI} satisfies the $[GT_i^{EI}]$ constraint with equality. This allows us to state the following observation.

Observation 1. When firms are differentiated with exogenous product lines, even if the incumbent could source the new product on its own at a lower cost, the firm would obtain better outcomes by sourcing the product from the entrant.

Proof. The proof follows from the above discussion (additional mathematical details in Appendix B). □

Even if the incumbent could introduce the product on its own, the firm does better by buying the product from the entrant and paying a wholesale price that is superior to the marginal production cost of the product. This outcome hinges in the reduction of the degree of competition (horizontal conflict) that ensues in scenario *ES* versus scenario *EI*. If the entrant sources the product independently, the price-increasing effect is inexistent and companies become more aggressive in their pursuit of the disputed consumers. Conversely, when the incumbent sources the product from the other firm, the higher wholesale price combined with the strategic complementarity of prices keeps firms from becoming too aggressive. Buying the product from the incumbent thus is a commitment device that allows firms to soften competition in consumer markets.

An example in the storage area illustrates this phenomenon. Although IBM has access to alternative sourcing capabilities, it nevertheless chooses to maintain a longstanding relationships with NetApps, which enables IBM to sell IBM branded solutions based on NetApp's unified storage solutions (IBM 2013).

4. Differentiated Firms with Endogenous Product Lines

In this section, we extend the model by fully endogenizing firms' product line decisions and considering

that both firms have the capability of producing both high- and low-quality products. Each firm thus has four possibilities regarding its production strategy: 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 supply one or both of the products to the other firm.[8]

To accommodate the firms' endogenous product-line decision, we revise the structure of the game (described in §2): in the first stage, the entrant makes the entry decision. In the second stage, firms make product-line and OEM decisions simultaneously. As in the previous model, if firms engage in an OEM arrangement, the wholesale price is determined by a Stackelberg process. 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 and we look for SPNE equilibria.

The procedure to compute demands and equilibrium prices and profits for the firms is similar to the one we adopted in §3.1; thus, we present the analysis in a concise manner. The detailed mathematical analysis is in Appendix C. We notice first that the possibility of firms producing both products implies that they can successfully compete for consumers when $t \in [(\lambda|c_{eH} - c_{iH}|)/3, [2v + \lambda(2\bar{\theta}\Delta - c_{eH} - c_{iH})]/3]$.

As in the exogenous product line case, the difference in brand images allows both firms to serve consumers who strongly prefer their respective brand. Hence, if the entrant enters the market on its own, profit for the firms, denoted as π^{E*}_{kHL}, is always positive.

However, the possibility that firms can produce both products on their own significantly changes the overall strategy of the firms as compared to the exogenous product line case. Our analysis reveals that two different types of equilibria may emerge: either each firm produces just one differentiated product and they become suppliers to each other (an outcome that we denote as *ESS*), or one of the firms becomes the sole producer and sells both product lines to consumers and to the other firm (an outcome that we denote as *ES*2).

The analysis also reveals that, in both equilibrium regimes, there exists a threshold value $\bar{\lambda}$ in the proportion of high-type consumers, such that when $\lambda < \bar{\lambda}$, there is no conflict between the firms. The Stackelberg leader sets the wholesale price of the low-quality product to the highest price that still allows firms to serve all low-type consumers ($w^*_L = w^{DD}_L \equiv v - 3t/2$), thus creating a touching equilibrium in this segment; the wholesale price of the high-quality product is set to the highest price that still allows firms to screen consumers ($w^*_H = \bar{\theta}\Delta + w^{DD}_L$).

On the other hand, when $\lambda > \bar{\lambda}$, vertical conflict between the firm emerges. If the Stackelberg leader is the producer of the high-quality product in the *ESS* equilibrium regime or the buyer of both products in the *ES*2 equilibrium regime, then the Stackelberg leader finds it optimal to serve all consumers by implementing the same wholesale prices as when $\lambda < \bar{\lambda}$. The Stackelberg follower accepts the arrangement because it automatically satisfies the gains-from-trade constraint ($\pi^{ESS}_{kq} \mid w_L, w_H \geq \pi^{E*}_{kHL}$ in the *ESS* equilibrium and $\pi^{ES2}_{k} \mid w_L, w_H \geq \pi^{E*}_{kHL}$ in the *ES*2 equilibrium).

Conversely, if the Stackelberg leader is the producer of the low-quality product in the *ESS* equilibrium regime or the producer of both products in the *ES*2 equilibrium regime, then the Stackelberg leader finds it optimal to ration out some of the low-type consumers (by implementing $w^*_L > w^{DD}_L$), which creates an endogenous local monopolistic outcome in this segment. This allows the wholesale price for the high-quality product w^*_H to be adjusted so as to extract more surplus from high-type consumers. This extra surplus is not shared equally by the firms because the Stackelberg leader can make offers for wholesale prices w_L and w_H that capture a higher proportion of the extra surplus; the Stackelberg follower would prefer the wholesale prices that serve all consumers, but it will accept the arrangement as long as the gains-from-trade constraint is satisfied.

The proposition below summarizes the outcomes in the endogenous product lines model.

Proposition 2. *When firms are differentiated and can produce both product lines and sell to each other, they will differentiate production by either producing just one product each, with distinct qualities and becoming OEM suppliers to each other* (*ESS equilibrium*), *or by establishing one of the firms as the sole producer and OEM supplier of both product lines* (*ES*2 *equilibrium*). *In these two cases, firms will sell both the high- and the low- quality products to consumers. Furthermore, there is a threshold value* $\bar{\lambda}$ *such that*:

(i) *If the proportion of high-type consumers is small* ($\lambda < \bar{\lambda}$), *there is no conflict between the firms. They will implement the highest wholesale prices and consumer prices that still enable them to serve all consumers.*

(ii) *If the proportion of high-type consumers is large* ($\lambda > \bar{\lambda}$), *firms have partially aligned incentives with respect to the wholesale prices. In equilibrium, the Stackelberg leader will implement wholesale prices that ration out some of the low-type consumers to extract more surplus from high-type consumers.*

[8] We still employ the labeling of incumbent and entrant to identify firms. However, because both firms have more flexibility in their product-line and OEM supply decisions, the distinction between the two firms is less consequential.

Proof. See Appendix C. □

The results in Proposition 2 are interesting because they go in contrast with established principles of optimal vertical product differentiation. For instance, the seminal paper by Shaked and Sutton (1982) suggests that firms should optimally select to offer to the market products of different vertical qualities; doing so relaxes competition for consumers because consumers with different preferences self-select to buy products of varying qualities offered by different firms. This difference in product qualities to a heterogeneous market reduces competition and increases firms' profits. In our model, however, firms optimally offer products of the same vertical qualities to the heterogeneous market and still relax competition due to the differentiation in product production—either firms differentiate production by producing different product lines or by having a firm producing both product lines while the other produces none. It deserves notice that this outcome can be more efficient than the traditional "maximum differentiation" outcome because it reduces competition (and conflict) while better accommodating consumer preferences. Below, we explain the forces behind this novel mechanism, which operate in both the *ESS* and the *ES*2 equilibrium regimes.

The firms' ability to produce both product lines enables each firm to target both segments of consumers independently of the other firm. 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 firms more aggressive in competing for the marginal consumer. These two effects compound and end up depressing consumer prices and firms' profits.

On the other hand, if firm k engages in an OEM supply arrangement selling one or both product lines to the competing firm 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. 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 $-k$ 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 supply arrangement than when they do not.

Furthermore, when firms are serving both consumer segments, they realize that low prices in a segment would force prices in the other segment to be low as well, thus further reducing the incentive for intense consumer price competition and also reducing the vertical conflict due to wholesale prices. When the proportion of low-type consumers is large ($\lambda < \bar{\lambda}$) and firms find it optimal to serve all consumers, the price increasing effect eliminates both the vertical and horizontal conflict between the firms, and they implement wholesale prices and consumer prices so that firms can extract maximum surplus from low-type consumers while giving some surplus to high-type consumers.

On the other hand, when the proportion of high-type consumers is large ($\lambda > \bar{\lambda}$), firms may have unaligned incentives with respect to whether to ration out some of the low-type consumers to capture more value from high-type consumers. In this case, conflict may emerge because firms would prefer different wholesale prices depending on what product they are sourcing to/from the other firm. Nevertheless, as in the exogenous product line case, the conflict between the firms is smaller than what it usually is in a standard vertical relationship. The rationale is that both firms desire wholesale prices that are not too low (reducing vertical conflict) to allow for the implementation of higher consumer prices (reducing horizontal conflict).

An example of companies selling each other's product lines is the OEM agreement between IBM and Compaq in the early 2000s in which the companies sold each others' key disk systems, giving each firm coverage in the mid-range and high-end storage markets (Hoannes and McWilliams 2000). IBM and Compaq had distinctive brands and chose to buy each other products, even though they were competing for consumers and had the possibility to produce or source the disk systems independently.

5. The Role of Homogeneity in Consumer Preferences

In the competitive environments we analyzed, we noticed that high wholesale prices can be profit increasing for both firms. A characteristic of these environments is that consumers had heterogeneous horizontal preferences for firms' brands as well as heterogeneous vertical preferences for product qualities. In this section we demonstrate the importance of consumer heterogeneous preferences in driving the results by investigating scenarios in which consumers have homogeneous preferences. We first examine the case in which consumers do not exhibit differences in tastes for vertical quality. Subsequently, we will examine the case in which consumers do not see significant differences between brands.

5.1. Consumers Have Homogeneous Tastes for Vertical Quality

In this scenario, consumers have homogeneous taste for vertical quality, which implies that there is only one segment of consumers. Either all consumers are low-type or all consumers are high-type.

5.1.1. Product Lines Are Exogenous. Consider first the situation in which firms have one product line each, with distinct vertical qualities. Our analysis in Appendix D shows that if the entrant produces a low-quality product, then entry-only is the ensuing outcome. The reason is that an OEM arrangement cannot be sustained in equilibrium because the entrant has an incentive to deviate from the arrangement and sell its own high-quality product to consumers.

Conversely, if the entrant produces a high-quality product, the ensuing outcome is entry combined with OEM supply. This equilibrium occurs because it is possible to find a wholesale price w that satisfies the $[GT_k]$ constraint $\pi_k^{ES} \mid w \geq \pi_k^{E*}$ for both firms. Thus, the entrant enters the market and establishes a supply relationship with the incumbent, who takes its own low-quality product out of the market and sells the entrant's high-quality product to those consumers who prefer the incumbent's brand.

The analysis also shows that the incumbent is indifferent to wholesale prices w as long as firms still compete for consumers (more specifically, as long as $w \leq w^{DD} \equiv \theta(v+\Delta) - 3t/2$), but it experiences a decrease in profits for higher wholesale prices ($w > w^{DD}$). On the other hand, the optimal profit for the entrant has an interior maximum that occurs at $w^{FOC} > w^{DD}$; thus, the entrant would desire to set the wholesale price at w^{FOC}. However, since profit for the incumbent decreases for values above w^{DD}, the constraint $[GT_i]$ may be binding. Consequently, if the incumbent is the Stackelberg leader, the equilibrium wholesale price is $w_i^* = w^{DD}$, whereas if the entrant is the Stackelberg leader, the equilibrium wholesale price is $w_e^* = \max\{w^{FOC}, w^{GT}\}$, where w^{GT} satisfies the $[GT_i]$ constraint with equality. In other words, the supplier would prefer a high price that is bounded by either a gains-from-trade constraint or by the losses of double marginalization.

In an analysis similar to that in §3.2, we find that if the buyer in an OEM relationship had the option to source the high-quality product on its own at a cheaper marginal costs, it would do so. More precisely, if firm k can be guaranteed a marginal cost $c_k < c_{-k}$, it would obtain profit of $\pi_k^{EI*} = (3t - c_k + c_{-k})^2/(18t)$, which is higher than the maximum it could get by engaging in an OEM relationship (which is $\pi_k^{ES} = t/2$).

5.1.2. Product Lines Are Endogenous. Next consider the situation in which firms can decide on product lines endogenously and become suppliers to each other. In this case, the equilibrium is for the entrant to always enter the market and establish an OEM arrangement with the incumbent. Although firms do not need each other to be able to offer high-quality products to consumers, they can reach a Pareto improving outcome in which the low-cost manufacturer supplies the high-quality product to the high-cost manufacturer. This latter result is driven mostly both by a reduction in overall production costs. The firms' incentives with respect to the wholesale price are similar to those in the exogenous product lines case, in the sense that if the buyer is the Stackelberg leader the equilibrium wholesale price is w^{DD}, whereas if the seller is the Stackelberg leader, the equilibrium is $\max\{w^{FOC}, w^{GT}\}$. In addition, a potential buying firm would prefer to source the product independently at a lower cost than to buy from the other firm.

The results in Appendix D also identify the ensuing outcomes in case firms were vertically undifferentiated. If both firms had low-quality products, no OEM relationship would be established because firms could neither improve on value provision nor save on production costs. On the other hand, if both firms had high-quality products, the equilibrium outcome would be exactly as in the endogenous product lines case: the lowest-cost producer of the high-quality product would supply it to the other firm.

5.1.3. Summary of Results. The result for the two scenarios in which consumers have homogeneous vertical tastes are formalized in the following proposition.

Proposition 3. *When firms are horizontally differentiated and consumers have homogeneous vertical tastes, the entrant always enters the market. Furthermore,*

(i) *If product lines are exogenous, the entrant supplies its product to the incumbent only if the former produces a high-quality product.*

(ii) *If firms can produce both product qualities, the low-cost producer of the high-quality product supplies it to the high-cost producer.*

In both situations, if the potential buying firm could source the product independently at a lower marginal cost than that produced by the selling firm, the buyer would obtain better outcomes by sourcing independently.

Proof. See Appendix D. □

Before we discuss the results from Proposition 3, we present the scenario of homogeneous horizontal preferences.

5.2. Consumers Have Homogeneous Horizontal Tastes

In this scenario, consumers do not see significant differences between firms ($t = 0$). The only possibility of differentiation is the quality of the products.

5.2.1. Product Lines Are Exogenous. Consider the situation in which firms have one product line each, with different vertical qualities. Appendix E shows that 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. Thus, the overall outcome for the firms, which we denote as π_k^{E*}, is severely depressed.

On the other hand, if the entrant were to stay out of the market and supply the product to the incumbent, the latter would be able to extract maximum surplus from consumers by directing the low-quality product to low-type consumers and charging the price $\underline{p}_i = v$ and the high-quality product to high-type consumers and charging the price $\bar{p}_i = v + \bar{\theta}\Delta$ (the maximum price that still screens consumers). The outcome for the firms conditional on the wholesale price w, which we denote as $\pi_k^S \mid w$, would be such that $\pi_i^S \mid w + \pi_e^S \mid w > \pi_i^{E*} + \pi_e^{E*}$, allowing firms to find a wholesale price w that makes it better for both of them to engage in an OEM arrangement.

Our analysis also shows that the incumbent and the entrant have opposite 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 the gains-from-trade condition $\pi_k^S \mid w \geq \pi_k^{E*}$ will be binding with equality. If the incumbent is the Stackelberg leader, it will offer to the entrant a low wholesale price w^* such that the entrant ends up with an OEM outcome that is barely above the entry outcome ($\pi_e^S \mid w^* = \pi_e^{*E}$). Conversely, when the entrant is the Stackelberg 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 ($\pi_i^S \mid w^* = \pi_i^{*E}$).

5.2.2. Product Lines Are Endogenous. Next consider the situation in which firms can choose product lines endogenously and become suppliers to each other. When the incumbent is alone in the market, it will be producing both products since this allows the incumbent to screen consumers on its own.

Because firms are on an 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 product does not constitute a credible threat that forces the incumbent to buy the entrant's product. Furthermore, because both firms have the same production cost, firms cannot achieve higher efficiencies by agreeing on an OEM supply arrangement for that product.

With respect to the high-quality product, when the incumbent has a cost advantage ($c_{iH} < c_{eH}$), it would find it optimal to set the consumer price $\bar{p}_i$ 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 it could enter the market and earn positive profit by setting $\bar{p}_e$ just below c_{iH} and capturing 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 supply arrangement. Such an arrangement not only reduces the overall production cost of the product but also nullifies competition effects.

With respect to the wholesale prices, firms' incentives are as in the exogenous product line case. The incumbent (buyer) wants to pay as little as possible, whereas the entrant (seller) wants to sell as high as possible, thus the gains-from-trade condition $\pi_k^S \mid w \geq \pi_k^{E*}$ will be binding with equality and all of the extra surplus from the OEM supply arrangement is captured by the Stackelberg leader.

5.2.3. Summary of Results. The result for the two scenarios in which consumers have homogeneous horizontal tastes are summarized in Proposition 4.

Proposition 4. *When firms are vertically differentiated and consumers have homogeneous horizontal tastes, the entrant always stays out of the market. Furthermore,*

(i) *If product lines are exogenous, the entrant supplies its product to the incumbent only if the former produces a high-quality product.*

(ii) *If firms can produce both product qualities, the entrant will supply the high-quality product to the incumbent only if the former can produce it at a lower marginal cost.*

In both situations, whenever a supply relationship is established, the traditional vertical conflict between firms emerges.

Proof. See Appendix E. □

Propositions 3 and 4 highlight that heterogeneity (or not) of consumer preferences for vertical qualities and horizontal brand images can regulate the firms' strategies and the degree of conflict between them.

As presented in Proposition 3, when consumers have *homogeneous vertical tastes*, which is equivalent to

say that there is only one segment of consumers, the entrant always finds it optimal to enter the market. Market entry is enabled by firms' horizontal differentiation, which is not affected by homogeneity in vertical tastes. Both firms have some degree of market power and may sell to those consumers who locally prefer their respective brands. Furthermore, an OEM supply relationship can be established if the incumbent can only produce low-quality products because the OEM relationship enables firms to provide more value for consumers by selling high-quality products at both extremes of the Hotelling market. If product qualities are exogenous and firms can sell to each other, an OEM supply in which the lowest-cost producer of the high-quality product supplies it to the other firm is always established. In this case, the value provided to consumers is the same with or without an OEM supply agreement, but the channel can save on production costs.

It is worth noting that (in contrast to when consumers have heterogeneous horizontal and vertical tastes) if the potential buying firm could source the product at a smaller marginal cost than that of the potential selling firm, the potential buyer would gladly source the product on its own because it would obtain better outcomes. This result occurs because, in the homogeneous vertical tastes scenario, profit for the buying firm never increases with high wholesale prices because the effect of strategic complementarity of prices never overpowers the direct effect of marginal cost savings.

Conversely, Proposition 4 establishes that when consumers have *homogeneous horizontal tastes*, which is equivalent to saying that firms are horizontally undifferentiated, entry by the entrant would trigger intense competition between the two firms because of the lack of horizontal differentiation. Even if the entrant could earn some positive profit by entering the market, which could happen when firms have different product lines or when the entrant has a cost advantage, the entrant can do better by selling its product to the incumbent and allowing the latter to be a monopolist in the market. This allows the incumbent to sustain high consumer prices and extract maximum surplus from consumers. In this situation, the horizontal conflict between firms is null because the incumbent remains a monopolist. However, firms experience the maximum degree of vertical conflict because the buyer (seller) desires the minimum possible (maximum) possible wholesale price.

6. Discussion and Conclusion

The decision whether to engage in a dual-channel relationship with rebranding is very complex. Past research has shown that these relationships may lead to significant conflict between channel partners. Our findings advance the literature by demonstrating that the dual-channel relationship can, under certain conditions, be an instrument that mitigates both horizontal and vertical conflict between channel partners and that stronger conflict could ensue if the relationship was not established.

Our findings came from the investigation of a market-entry model in which an entrant has the opportunity to enter the market and compete with the incumbent and/or sell its product to the incumbent in an OEM supply arrangement. Our analysis has shown that when firms are horizontally differentiated but still compete for consumers, if firms produce products of different vertical qualities, it is profitable for the entrant to not only enter the market but also to engage in an OEM supply relationship with the incumbent. Furthermore, we discovered that the buyer and the seller benefit by agreeing on wholesale prices for the OEM product that are not too low. The reason is that the relatively high wholesale price acts as a commitment device that softens price competition in the market. This finding is interesting because in typical vertical channel relationships, the buyer would like to purchase the product with the minimal possible price, whereas the seller wants higher prices. We found, instead, that when firms compete in multiple markets, the vertical conflict is reduced by the desire of both firms to avert the excessive price competition (horizontal conflict) that would ensue if the OEM supply relationship were not established or if the wholesale prices were too small. Because of the same strategic effects, we also found that even if an incumbent firm was able to source the OEM product independently, both firms can achieve better outcomes when the incumbent foregoes independent sourcing and instead engages in an OEM supply relationship with the entrant (again, with wholesale prices that are not too low).

We also discovered that if firms can match each other's product qualities, they find it optimal to differentiate production and engage in an OEM relationship so that both firms end up offering the same product qualities to consumers. This result is interesting in light of previous research in competitive environments that finds that firms will optimally choose to differentiate the products they offer to consumers so as to reduce the effect of price competition that typically occurs when similar goods are offered to the market. In fact, under certain conditions, both the horizontal and vertical conflicts between firms are completely nullified. The reason for this phenomenon hinges on two forces that operate simultaneously: (a) as in the exogenous product line case, the OEM supply relationship between the firms allows for optimal wholesale prices that are not too low and

prevents consumer prices (in all segments) from dipping and (b) the arrangement reduces the marginal return of selling to a consumer, thus making firms less aggressive when attempting to generate demand from the contested consumers.

Some of the traditional reasons for establishing a dual-channel chain did show up in other scenarios in our model. For instance, when consumers have homogeneous vertical tastes, and firms thus face only one segment of consumers, an entrant that produces high-quality products will enter the market and sell to an incumbent that produces low-quality products because this enables firms to provide more value to consumers. If firms can produce both product lines independently, OEM supply from a low-cost to a high-cost producer is established because it enables firms to benefit from cost efficiencies. These supply arrangements are not as efficient in reducing conflict between the firms (as when consumers have heterogeneous horizontal and vertical preferences) because the buying firm never benefits from higher wholesale prices and would not forego the opportunity to independently procure the high-quality product at lower marginal costs. On the other hand, when consumers have homogeneous horizontal tastes, and firms thus are vertically differentiated only, an OEM supply relationship is an instrument that prevents firms from engaging in fierce Bertrand competition and may enable the incumbent to offer a more complete product line and extract more surplus from consumers; it may also be an instrument to enable higher production efficiencies by allowing a low-cost producer to take charge of manufacturing goods. The OEM arrangement, however, causes firms to take completely opposite stances with respect to the wholesale price.

6.1. Robustness, Limitations, and Future Research

Our model follows a Hotelling market specification. 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 provided the cross-price effect is not too small in comparison to the own-price effect. The use of a Hotelling demand system does produce a particular result in the horizontally undifferentiated market: either all consumers of a segment buy the product of a firm, or no consumer buys the product. This peculiarity causes the inexistence of double marginalization in the horizontal undifferentiated scenarios. We predict that if a different demand system were to be used instead, double marginalization could become an issue. This would cause a minor change in the result when the entrant is the Stackelberg leader: the firm could find it optimal not to extract all the extra surplus produced by the OEM relationship through the wholesale price. In any event, this is not a significant limitation of the model since it does not change the entrant's market entry strategy nor the qualitative results about channel conflict.

We assumed that the firm's brand image would lead to horizontal differentiation between firms, whereas product characteristics would lead to vertical differentiation. This interpretation can be industry dependent. In some industries, brands can convey a signal of vertical quality (for instance, in watches, business suits, etc.). Therefore, readers should rely more on the distinction of horizontal and vertical differentiation than in brand image and product characteristics when applying the results of our research.

In our model, the OEM contracting between firms is based on the wholesale price only, a type of contract that is very conventional and that tends to be administratively cheaper than other forms of contracts (Cachon and Lariviere 2005). Many of the qualitative results of our model are robust to other forms of vertical contracting explored in the literature, such as a two-part tariff contract. The use of a two-part tariff would not change the OEM/entry mode strategy of the firms, although it could change the overall approach to setting the wholesale price in the horizontally differentiated cases: with a two-part tariff contract, the channel does better by setting the wholesale price so that firms barely touch at the center of the market and transferring rent through the fixed fee. This means that wholesale prices would be identical to those that happen in our model when the buying firm is the Stackelberg leader. This also implies that if the seller is the Stackelberg leader, the adoption of two-part tariff in our model would cause wholesale prices to increase (which is an interesting phenomenon because in the typical bilateral channel model, two-part tariffs cause prices to decrease). 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 Stackelberg follower to the Stackelberg leader. Of course, these observations are based on the models we analyzed, and one may expect that changes in contractual forms can play a major role in different market or competitive structure specifications.

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, and erection of entry barriers) to investigate how an incumbent could influence entry and OEM strategies of a potential entrant.

6.2. Managerial Implications

Our results give some interesting practical insights. From the standpoint of an entrant, entering a new market is more profitable when the firm's brand image can establish a meaningful differentiation element in the eyes of consumers. Absent this difference, a potential entrant does better by staying out of the market and helping an established incumbent to either expand its product lines or to achieve higher cost efficiencies. If an entrant has a differentiated brand and enters the market, there are multiple situations in which one of the competing firms can increase profits by selling its product to its competitor. These enter-and-supply strategies are optimal when the supplier's product helps the channel achieve at least one of the following: better value provision to consumers due to the offering of higher quality products to all consumers; better surplus extraction from consumers by enabling the targeting of different products to different consumer segments; or better production efficiencies through savings in overall production costs.

Contrary to expectation, once differentiated firms are competing in a multisegment market and engage in an OEM relationship, both the buyer and the seller can increase profits by agreeing on wholesale prices that are not too low. In fact, even if the potential buyer could source an additional product line independently and cheaply, the potential buyer firm can obtain more profit by sourcing the product line from its competitor and paying higher wholesale prices. If the firms have the capability of producing each other's product lines, the best strategy for them is to differentiate production by either producing different product lines and selling to each other or allocating all the production to a firm who supplies the others. This strategy enables all firms to match consumers' preferences for different product qualities and at the same time prevents them from engaging in fierce price competition.

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Appendix A. Proof of Proposition 1

We first compute the outcomes in the second stage (pricing subgame) and then identify the optimal strategies in the first stage (OEM and entry decisions).

Analysis of the Second Stage

Outcomes for Entry Only (*E*). Start by computing the outcomes when firms go to market independently. By using the demand expression from (1), we write the firms' profit expressions as

$$\pi_k^E = (p_k - c_k)\left[\lambda\left(\frac{1}{2} + \frac{[V(\bar{\theta}, q_k) - V(\bar{\theta}, q_{-k})] - (p_k - p_{-k})}{2t}\right) + (1-\lambda)\left(\frac{1}{2} + \frac{[V(\underline{\theta}, q_k) - V(\underline{\theta}, q_{-k})] - (p_k - p_{-k})}{2t}\right)\right].$$

By taking derivatives with respect to prices and simultaneously solving the first order conditions for p_k, the optimal prices for the firms are obtained:

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

Once these prices are substituted back into the original profit expressions, the optimal profits for the firms can be expressed as:

$$\pi_k^{E*} = \frac{1}{18t}\big(\{3t - c_k + c_{-k} + \lambda[V(\bar{\theta}, q_k) - V(\bar{\theta}, q_{-k})] + (1-\lambda)[V(\underline{\theta}, q_k) - V(\underline{\theta}, q_{-k})]\}^2\big). \quad \text{(A1)}$$

Checking the regularity conditions. Substitute the optimal prices on the demand functions to find that the firm producing the high-quality product has demand $D_{\underline{\theta}H} = \frac{1}{2} + \{[1 - 2\lambda(\theta-1)]\Delta + 3t - |c_i - c_e|\}/(6t)$ from low-type consumers and $D_{\bar{\theta}H} = \frac{1}{2} + \{[(3\theta-2) - 2\lambda(\theta-1)]\Delta + 3t - |c_i - c_e|\}/(6t)$ from high-type consumers. By solving the inequalities $D_{\underline{\theta}H} < 1$ and $D_{\bar{\theta}H} < 1$ for t we find that $t > [(3\theta-2)\Delta - |c_i - c_e|]/3$ guarantees that firms can compete for at least one consumer in each segment. Next, use the optimal prices and the indifference point to compute the utility of the marginal consumer in the low-type consumers segment to be $u_{\underline{\theta}} = (2v + \Delta - 3t - c_i - c_e)/(6t)$. Solve the inequality $u_{\underline{\theta}} > 0$ for t to find that $t < (2v + \Delta - c_i - c_e)/3$ guarantees positive utility, implying that firms do not become local monopolists.

Outcomes for OEM Combined with Entry (*ES*). Below, we compute the outcomes for the case in which the incumbent produces a high-quality product and the entrant produces a low-quality product. The proof for the reverse situation is very similar; thus, it is suppressed.

As it will become clear, the value of the wholesale price w can induce different equilibrium regimes in the pricing subgame. Therefore, we first compute the outcomes for each possible case and then we integrate the results by showing how the equilibrium regimes could transition from one regime to the next depending on w.

Scenario ES_cHL. If firms compete for consumers in both segments, which we label as *ES_cHL*, we can use the demand in expression (1) to write the profit functions for the firms.

Considering that the incumbent buys the low-quality product from the entrant and directs this product to low-type consumers while it directs its own high-quality

product to high-type consumers, the incumbent's profit expression is

$$\pi_{iH}^{ES} = (\bar{p}_i - c_{iH})\lambda\left(\frac{1}{2} + \frac{\bar{\theta}\Delta - \bar{p}_i + p_e}{2t}\right) + (\underline{p}_i - w)(1-\lambda)\left(\frac{1}{2} - \frac{\underline{p}_i - p_e}{2t}\right).$$

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

$$\pi_{eL}^{ES} = p_e\left[\lambda\left(\frac{1}{2} - \frac{\bar{\theta}\Delta - \bar{p}_i + p_e}{2t}\right) + (1-\lambda)\left(\frac{1}{2} + \frac{\underline{p}_i - p_e}{2t}\right)\right] + w(1-\lambda)\left(\frac{1}{2} - \frac{\underline{p}_i - p_e}{2t}\right).$$

By maximizing the firms' profit function subject to the $[IC_{\underline{\theta}}]$ constraint[9] we find that consumer prices as a function of the wholesale price w are

$$\bar{p}_{iL}^{ES\_cHL} = \frac{3[\Delta + t + (1-\lambda)w] - \lambda[(3-\bar{\theta})\Delta - 2c_{iH}]}{3},$$

$$\underline{p}_{iL}^{ES\_cHL} \mid w = \frac{3[t + (1-\lambda)w] - \lambda[(3-\bar{\theta})\Delta - 2c_{iH}]}{3},$$

$$p_{eH}^{ES\_cHL} \mid w = t + \frac{3[t + (1-\lambda)w] - \lambda(\bar{\theta}\Delta - 2c_{iH})}{3}.$$

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

$$\pi_{iH}^{ES\_cHL} \mid w = \frac{[3t + \lambda(\bar{\theta}\Delta - c_{iH})]^2 + 9\lambda(1-\lambda)(\bar{\theta}-1)\Delta(\Delta + w - c_{iH})}{18t},$$

$$\pi_{eL}^{ES\_cHL} \mid w = \frac{[3t - \lambda(\bar{\theta}\Delta - c_{iH})]^2 + 9(1-\lambda)w[2t + \lambda(\bar{\theta}-1)\Delta]}{18t}.$$

By checking the $[DD_{\theta}]$ conditions, we find that they are indeed met whenever $w \le w^{DD} \equiv (2v - 3t + \lambda(\Delta - c_{iH})/2(1-\lambda)$. For all $w \le w^{DD}$ the competitive outcome will ensue.

We take derivatives of $\pi_{iH}^{ES\_cHL} \mid w$, and $\pi_{eL}^{ES\_cHL} \mid w$ with respect to w, and find that

$$\frac{\partial(\pi_{iH}^{ES\_cHL} \mid w)}{\partial w} = \frac{\lambda(1-\lambda)(\bar{\theta}-1)\Delta}{2t} > 0,$$

$$\frac{\partial(\pi_{eL}^{ES\_cHL} \mid w)}{\partial w} = \frac{(1-\lambda)[2t + \lambda(\bar{\theta}-1)\Delta]}{2t} > 0.$$

Finally, we compute the optimal demand from low-type consumers in this equilibrium regime, which will be needed in a future step of this proof:

$$D_{\underline{\theta}i}^{ES\_cHL} = \frac{3t - \lambda[(2\bar{\theta}-3)(\Delta + c_{iH})]}{6t},$$

$$D_{\underline{\theta}e}^{ES\_cHL} = \frac{3t + \lambda[(2\bar{\theta}-3)(\Delta + c_{iH})]}{6t}. \tag{A2}$$

[9] The $[IC_{\underline{\theta}}]$ constraint will be binding since high wholesale prices have a higher impact on $\underline{p}$. We use the distorted prices because if *ES* strategy is optimal with constrained prices, it is optimal with unconstrained prices as well.

Scenario ES_cHmL. If w is in a level that causes firms to compete for high-type consumers but end up being de facto local monopolists in the low-type segment, which we call *ES_cHmL*, we can use the demand expressions from (1) and (3) to rewrite the firm's profit expressions as

$$\pi_{iH}^{ES} = (\bar{p}_i - c_{iH})\lambda\left(\frac{1}{2} + \frac{\bar{\theta}\Delta - \bar{p}_i + p_e}{2t}\right) + (\underline{p}_i - w)(1-\lambda)\frac{v - \underline{p}_i}{t},$$

$$\pi_{eL}^{ES} = p_e\left[\lambda\left(\frac{1}{2} - \frac{\bar{\theta}\Delta - \bar{p}_i + p_e}{2t}\right) + (1-\lambda)\frac{v - p_e}{t}\right] + w(1-\lambda)\frac{v - \underline{p}_i}{t}.$$

By maximizing these profit expressions with respect to prices, and subject to the $[IC_{\underline{\theta}}]$ constraint, we find that consumer prices as a function of the wholesale price w are

$$\bar{p}_{iH}^{ES\_cHmL} \mid w = \Delta + \left[\lambda^2(3t + \bar{\theta}\Delta - 3\Delta + 2c_{iH}) + 8(1-\lambda)^2(v + \Delta + w) + 2\lambda(1-\lambda)(2t + 3v - 2\Delta + 2\bar{\theta}\Delta + 2c_{iH} + 2w)\right] \cdot \left[(4-\lambda)(4-3\lambda)\right]^{-1},$$

$$\underline{p}_{iH}^{ES\_cHmL} \mid w = \left[\lambda^2(3t + \bar{\theta}\Delta - 3\Delta + 2c_{iH}) + 8(1-\lambda)^2(v + \Delta + w) + 2\lambda(1-\lambda)(2t + 3v - 2\Delta + 2\bar{\theta}\Delta + 2c_{iH} + 2w)\right] \cdot \left[(4-\lambda)(4-3\lambda)\right]^{-1},$$

$$p_{eL}^{ES\_cHmL} \mid w = \left[\lambda^2(3t - \bar{\theta}\Delta + c_{iH}) + 8(1-\lambda)^2 v + 2\lambda(1-\lambda) \cdot (2t + 3v + 3\Delta - 2\bar{\theta}\Delta + w)\right] \cdot \left[(4-\lambda)(4-3\lambda)\right]^{-1}.$$

The conditional profit expressions for $\pi_{iH}^{ES\_cHmL} \mid w$ and $\pi_{eL}^{ES\_cHmL} \mid w$ follow directly from substituting these prices in the original objective functions.

To check the effect of changes in w on firms' profit outcomes, we use implicit differentiation and find that $\partial\pi_{iH}^{ES\_cHmL}/\partial w = -(1-\lambda)\{8(v-w) - 4[p_e + c_{iH} + t + v - 3w + \Delta(\bar{\theta}-2)]\lambda + [2p_e + 3c_{iH} + 2t - v - 4w + \Delta(2\bar{\theta}-5)]\lambda^2\}/[t(4-\lambda)\cdot(4-3\lambda)]$. This expression is unequivocally negative for $w \le v$.

We follow a similar implicit differentiation process and find that $\partial\pi_{eL}^{ES\_cHmL}/\partial w = (1-\lambda)\{8(2v-w) - 2(7v-6w)\lambda + [t + v - 4w + \Delta(1-\bar{\theta})]\lambda^2 + 2\underline{p}_{iH}^{ES\_cHmL}[8 - (8-\lambda)\lambda]\}/[t(4-\lambda)\cdot(4-3\lambda)]$. By inspection, this expression is positive for small values of w and negative otherwise.

Consequently, we conclude that in this equilibrium regime, the impact of changes in w on firms' profits is as follows: for the incumbent, profits always decrease with w. For

the entrant, profits are initially increasing and then decreasing with w. By continuity of the profit expressions, there exists an interior w^{FOC} that maximizes firms profit in this regime.

Finally, we compute the optimal demand from low-type consumers in this equilibrium regime, which will be needed in the next step of this proof:

$$\begin{aligned} D_{\underline{\theta}i}^{ES\_cHmL} \mid w &= \{(2-\lambda)(4-\lambda)v \\ &\quad -4(2-\lambda)(1-\lambda)w-4\lambda[(\bar{\theta}-2)\Delta+t+c_{iH})] \\ &\quad +\lambda^2[(3\bar{\theta}-5)\Delta+t+2c_{iH})]\}\cdot[t(4-\lambda)(4-3\lambda)]^{-1}, \quad \text{(A3)} \\ D_{\underline{\theta}e}^{ES\_cHmL} \mid w &= \{8v-2\lambda[2t+3v-2(\bar{\theta}-1)\Delta+w] \\ &\quad +\lambda^2[t+v-(3\bar{\theta}-6)\Delta-c_{iH}+2w]\} \\ &\quad \cdot[t(4-\lambda)(4-3\lambda)]^{-1}. \quad \text{(A4)} \end{aligned}$$

Transition Between *ES* Equilibrium Regimes. We are now ready to identify how the actual equilibrium outcomes transition as a function of w. We do so by considering what happens with outcomes in the pricing subgame as w increases from small to large values.

For small values of w ($w < w^{DD}$), a competitive equilibrium with full market coverage will ensue.

When $w = w^{DD}$, firms' prices are such that the marginal consumer in the low-type consumer segment is obtaining zero utility from buying from each firm.

Consider what happens when w increases further. One may think that the entrant will increase prices accordingly. However, this may not be true if it nevertheless prefers to cover the market fully. This occurs when the optimal demand from low-type consumers in the (*ES_cHmL*) case is higher than that in the (*ES_cHL*) case. Formally, this occurs when $D_{\underline{\theta}i}^{ES\_cHL} < D_{\underline{\theta}i}^{ES\_cHmL} \mid w$ (from A2 and A3). Effectively, this means that the incumbent absorbs increases in the wholesale price without increasing its consumer price, which in turn causes the entrant to keep its consumer price constant as well. Consequently, we conclude that the effect of changing w on firms' profits is as follows: for the incumbent profit is strictly decreasing with w, but for the entrant profit is strictly increasing with w.

Notice, however, that because $D_{\underline{\theta}i}^{ES\_cHmL} \mid w$ is decreasing in w ($\partial(D_{\underline{\theta}i}^{ES\_cHmL} \mid w)/\partial w = -4(2-\lambda)(1-\lambda)/[t(4-\lambda)\cdot(4-3\lambda)] < 0$), further increases in w necessarily causes $D_{\underline{\theta}i}^{ES\_cHL} > D_{\underline{\theta}i}^{ES\_cHmL} \mid w$, changing the incumbent's preference. Therefore, for large enough values of w, the incumbent prefers to raise prices and reduce its optimal quantity. At this point, there are two possibilities.

If $D_{\underline{\theta}e}^{ES\_cHL} < D_{\underline{\theta}e}^{ES\_cHmL} \mid w$ (from A2 and A4), the entrant finds it optimal to reduce its price so as to capture the consumers rationed out by the incumbent. However, if $D_{\underline{\theta}e}^{ES\_cHL} > D_{\underline{\theta}e}^{ES\_cHmL} \mid w$, the entrant will find it optimal to increase its price and ration out consumers. To find the cutoff point we solve $D_{\underline{\theta}e}^{ES\_cHL} = D_{\underline{\theta}e}^{ES\_cHmL} \mid w$ for w and find that $w = w^{CUT} \equiv [2\Delta+2v(2-\lambda)-t(4-\lambda)-\lambda c_{iH}]/[2(1-\lambda)]$.

We observe that values of w at or above w^{CUT} are out of equilibrium because the $[GT_i]$ for the incumbent would be violated. To check this, consider that the highest likelihood that the (*ES_cHmL*) regime can be reached occurs when t assumes its maximum value. Next, notice that because in the (*E*) outcome every product the incumbent is selling has a cost c_{iH}, whereas in the (*ES_cHmL*) outcome only the fraction of products the incumbent sells to high-type consumers have this cost, an increase in the marginal cost c_{iH} hurts the (*E*) outcome more than the (*ES*) outcome. Hence, we substitute the maximum value for t and the maximum value for c_{iH} in the profit expressions for the (*E*) and (*ES_cHmL*) outcomes to get

$$\begin{aligned} \pi_i^{E*} &= \frac{[2v+\lambda(\theta-1)\Delta]^2}{12v}, \\ \pi_i^{ES\_cHmL} \mid w^{CUT} &= \{9(2-\lambda)\lambda^2(\theta-1)^2\Delta^2-12(5-2\lambda) \\ &\quad \cdot\lambda(\theta-1)v\Delta+4v^2[2+\lambda(7+\lambda+\lambda^2)]\} \\ &\quad \cdot[12v(4-\lambda)^2]^{-1}. \end{aligned}$$

The difference between these outcomes is $\pi_i^{ES\_cHmL} \mid w^{CUT} - \pi_i^{E*} = (1-\lambda)[(2+\lambda)\lambda^2(\theta-1)^2\Delta^2 - 4(14-5\lambda)\lambda(\theta-1)\cdot v\Delta - 4v^2(14-\lambda+\lambda^2)]/[12v(4-\lambda)^2]$. This expression is negative unless θ is extremely high, but this would make it impossible to find values that satisfy the regularity conditions for the parameter t. Thus, we conclude that $[GT_i]$ cannot be satisfied when $w \geq w^{CUT}$. A direct implication is that a value of w that makes firms local monopolists in both segments is also off the equilibrium.

Outcomes for Supply Only (*S*). For the entrant, the (*S*) outcome is strictly dominated by the (*ES*) outcome because the firm can always increase profit by selling to those consumers who locally prefer its brand.

Outcomes if the Incumbent Drops Its Own Product. Because of our assumptions in the model setup, 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 the (*ES*) outcome.

Analysis of the First Stage. Given the outcomes above, the entrant's optimal strategy is to enter the market and also to supply its product to the incumbent. If the incumbent is the Stackelberg leader, it proposes to buy the product at a price $w_i^* = w^{DD}$ and a touching equilibrium configuration emerges in the low-type consumers segment. Notice that because $\pi_k^{ES} \mid w$ is increasing in w for both firms when $w \leq w^{DD}$, we can unequivocally state that $[GT_k]$ is satisfied for both firms. On the other hand, if the entrant is the Stackelberg leader, it proposes to sell the OEM product at a price $w_e^* = \max\{w^{FOC}, w^{GT}\}$, where w^{GT} solves $\pi_i^{ES} \mid w^{GT} = \pi_i^{E*}$ with equality. □

Appendix B. Proof of Observation 1

Comparing Sourcing on Its Own (*EI*) with Entry Only (*E*). First, notice that given the discussion in the Initial Considerations in §3.1, it should be intuitive that if the incumbent can produce and sell both product qualities on its own, its outcome is never inferior than what it obtains by selling just one product quality ($\pi_{iHL}^{EI*} \geq \pi_{iq}^{E*}$).

Suppose that parameters are such that $\pi_{iHL}^{EI*} = \pi_{iq}^{E*}$. In such case, the proof of Proposition 1 already established that scenario *ES* dominates scenario *E* and we are done.

On the other hand, suppose that $\pi_{iHL}^{EI*} > \pi_{iq}^{E*}$. An immediate implication is that we need to rewrite the $[GT_i]$ constraint for the incumbent as $[GT_i^{ES}]$: $\pi_{iHL}^{ES*} \geq \pi_{iHL}^{EI*}$. This means that the wholesale price that solves $[GT_i^{ES}]$ with equality, which we call w^{GT_EI}, is shifted to the left with respect to w^{GT} (in the proof of Proposition 1). In other words, $w^{GT\_EI} \leq w^{GT}$.

Comparing Sourcing on Its Own (*EI*) with OEM Combined with Entry (*ES*). Consider the situation in which the entrant is producing a low-quality product. The outcome in scenario *EI* is the same as that in scenario *ES* if the wholesale price is fixed to be the entrant's marginal cost ($\pi_{kHL}^{EI*} = \pi_{kHL}^{ES*}$). The reason is that, for the incumbent, the actual source of the product does not affect the firm's objective function; for the entrant, the setting is equivalent to a situation in which the entrant is not supplying the product, since it receives a net revenue of zero from the incumbent.

This can be confirmed by rewriting the objective functions for the firms as

$$\pi_{kHL}^{EI} = (\bar{p}_k - c_{kH})\lambda\left(\frac{1}{2} + \frac{\bar{\theta}\Delta - \bar{p}_k + p_{-k}}{2t}\right) + \underline{p}_k(1-\lambda)\left(\frac{1}{2} - \frac{\underline{p}_k - p_{-k}}{2t}\right),$$

$$\pi_{-kL}^{EI} = p_{-k}\left[\lambda\left(\frac{1}{2} - \frac{\bar{\theta}\Delta - \bar{p}_k + p_{-k}}{2t}\right) + (1-\lambda)\left(\frac{1}{2} + \frac{\underline{p}_k - p_{-k}}{2t}\right)\right].$$

By solving for the first-order conditions, subject to the $[IC_{\theta k}]$ constraint, we find profits for the incumbent of: $\pi_{iHL}^{EI*} = \{3t^2 + 6t\lambda(\bar{\theta}\Delta - c_{kH}) + 9\lambda(1-\lambda)[(\bar{\theta}-1)\Delta]\}/(18t)$.

The difference $\pi_{iHL}^{ES*} - \pi_{kHL}^{EI*} = \lambda(1-\lambda)(\bar{\theta}-1)\Delta w/(18t)$. It is straightforward to see this difference is zero when $w = c_{eL} = 0$ and positive when $w = w^{DD}$. This means that the incumbent prefers the *ES* outcome. The same logic applies when the entrant has a high-quality product. □

Appendix C. Proof of Proposition 2

Remark. Throughout this proof, we use the use the (boldface) vector $\mathbf{w}$ to refer to the wholesale prices of both products: $\mathbf{w} = \{w_H, w_L\}$.

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 1. *If firms can produce both product qualities on their own, they 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 bring a second product to the market (either by producing it or sourcing it). Similarly, if firm k had no product, it would find it better to produce or source products to sell to those consumers who locally prefer its brand. □

Analysis of the Final Stage

Both Firms Manufacture Both Products (*E*). In this case, both firms sell their own products to consumers. We use the demand in expression (1) to write the profit functions for the firms:

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

It can be confirmed from the first-order conditions that the optimal solution to this problem yields outcomes of $\pi_{kHL}^{E*} = t/2 + \{\lambda[(c_{-kH} - c_{kH})^2 + 6t(c_{-kH} - c_{kH})]\}/(18t)$. Using a procedure similar to that in the proof of Proposition 1, we find that when $(\lambda|c_{eH} - c_{iH}|)/3 < t < [2v + \lambda(2\bar{\theta}\Delta - c_{eH} - c_{iH})]/3$, all consumers are served and firms compete for at least one consumer in each segment.

A Firm Does Not Manufacture Products; the Other Manufactures Two Products (*ES*2). Suppose firm k manufactures both product lines and the other firm $(-k)$ does not. By Claim 1, firm $-k$ buys both products from k.

Scenario ES2_cHL. Consider first a situation in which firms serve all consumers. In this case, the objective functions for the firms are

$$\pi_{kHL}^{ES2} = (\bar{p}_k - c_{kH})\lambda\left(\frac{1}{2} - \frac{\bar{p}_k - \bar{p}_{-k}}{2t}\right) + \underline{p}_k(1-\lambda)\left(\frac{1}{2} - \frac{\underline{p}_k - \underline{p}_{-k}}{2t}\right) + (w_H - c_{kH})\lambda\left(\frac{1}{2} + \frac{\bar{p}_k - \bar{p}_{-k}}{2t}\right) + w_L(1-\lambda)\left(\frac{1}{2} + \frac{\underline{p}_k - \underline{p}_{-k}}{2t}\right),$$

$$\pi_{-k}^{ES2} = (\bar{p}_{-k} - w_H)\lambda\left(\frac{1}{2} + \frac{\bar{p}_k - \bar{p}_{-k}}{2t}\right) + (\underline{p}_{-k} - w_L)(1-\lambda)\left(\frac{1}{2} + \frac{\underline{p}_k - \underline{p}_{-k}}{2t}\right).$$

From the first-order conditions, we can confirm that the optimal profits for the firms, conditional on $\mathbf{w}$, are

$$\pi_k^{ES2\_cHL*}|\mathbf{w} = \frac{t}{2} + \lambda(w_H - c_{kH}) + (1-\lambda)w_L, \quad \pi_{-kLH}^{ES2\_cHL*}|\mathbf{w} = \frac{t}{2}.$$

Firm k optimally implements the highest wholesale price for the low-quality product that still serves all consumers, which is $w_L^{ES2\_cHL*} = w_L^{DD} \equiv v - 3t/2$ and the maximum wholesale price $w_H^{ES2\_cHL*} = v + \bar{\theta}\Delta - t/2$ that respects $[IC_{\bar{\theta}}]$,[10] This will enable consumer prices to be $\underline{p}_k^{ES2\_cHL*} = v - t/2$

[10] The $[DD_\theta]$ condition is binding for low-type segment and the $[IC_\theta]$ constraint is binding for high-type consumers. The reason is that if the $[DD_\theta]$ conditions were binding in both segments, the high-valuation consumers would find it optimal to trade down and pay less to buy the low-quality product, whereas low-valuation consumers do not find it optimal to trade up and pay more to buy the high-quality product.

and $\bar{p}_k^{ES2\_cHL*} = v + \bar{\theta}\Delta - 3t/2$, and firms end up in a touching competitive equilibrium in the low-type consumers segment. The ensuing outcomes for the firms will thus be

$$\pi_k^{ES2\_cHL*} = v + \lambda(\bar{\theta}\Delta - c_{kH}) - t, \quad \pi_{-kLH}^{ES2\_cHL*} = \frac{t}{2}.$$

Scenario ES2_cHmL. Next consider a situation in which firms may ration out some of the low-type consumers to extract more surplus from the high-type consumers. If firms were to do so, the objective function for the firms would be

$$\pi_{kHL}^{ES2} = (\bar{p}_k - c_{kH})\lambda\left(\frac{1}{2} - \frac{\bar{p}_k - \bar{p}_{-k}}{2t}\right) + \underline{p}_k(1-\lambda)\left(\frac{v - \underline{p}_k}{t}\right) + (w_H - c_{kH})\lambda\left(\frac{1}{2} + \frac{\bar{p}_k - \bar{p}_{-k}}{2t}\right) + w_L(1-\lambda)\left(\frac{v - \underline{p}_{-k}}{t}\right),$$

$$\pi_{-k}^{ES2} = (\bar{p}_{-k} - w_H)\lambda\left(\frac{1}{2} + \frac{\bar{p}_k - \bar{p}_{-k}}{2t}\right) + (\underline{p}_{-k} - w_L)(1-\lambda)\left(\frac{v - \underline{p}_{-k}}{t}\right).$$

By maximizing subject to the $[IC_{\bar{\theta}}]$ constraint, we find the optimal prices conditional on $\mathbf{w}$:

$$\underline{p}_{kHL}^{ES2\_cHmL}|\mathbf{w} = [2v(4-5\lambda+\lambda^2) - 2\lambda(1-\lambda)w_L + \lambda(4-\lambda)(t - \bar{\theta}\Delta + w_H)]\cdot[(4-\lambda)(4-3\lambda)]^{-1},$$

$$\bar{p}_k^{ES2\_cHmL}|\mathbf{w} = \bar{\theta}\Delta + \underline{p}_{kHL}^{E2\_cHmL}|\mathbf{w},$$

$$\underline{p}_{-k}^{ES2\_cHmL}|\mathbf{w} = [2v(4-5\lambda+\lambda^2) + 4(2-3\lambda+\lambda^2)w_L + \lambda(4-\lambda)(t - \bar{\theta}\Delta + w_H)]\cdot[(4-\lambda)(4-3\lambda)]^{-1},$$

$$\bar{p}_{-k}^{ES2\_cHmL}|\mathbf{w} = \bar{\theta}\Delta + \underline{p}_{-k}^{E2\_cHmL}|\mathbf{w}.$$

The conditional profits $\pi_{kHL}^{E2\_cHmL}|\mathbf{w}$ and $\pi_{-k}^{E2\_cHmL}|\mathbf{w}$ are obtained by substituting the prices above in the original objective functions.

One can take derivatives with respect to $\mathbf{w}$ and substitute $\mathbf{w}^{ES2\_cHL*}$ to verify that at this point

$$\frac{\pi_{kHL}^{ES2\_cHmL}|\mathbf{w}}{\partial w_L} > 0, \quad \frac{\pi_{kHL}^{ES2\_cHmL}|\mathbf{w}}{\partial w_H} > 0,$$

$$\frac{\pi_{-k}^{ES2\_cHmL}|\mathbf{w}}{\partial w_L} < 0, \quad \text{and} \quad \frac{\pi_{-k}^{ES2\_cHmL}|\mathbf{w}}{\partial w_H} < 0.$$

Therefore, if firm k (the OEM seller) is the Stackelberg leader in the *cHmL* scenario at $\mathbf{w}^{ES2\_cHL*}$, it will choose to increase $\mathbf{w}$ so as to extract more surplus from consumers and from firm $-k$.

A game theoretical argument (a more detailed analysis is available upon request) allows us to conclude that there is a $\bar{\lambda}$ such that if $\lambda < \bar{\lambda}$ the Stackelberg leader optimally implements *cHL*; conversely, when $\lambda > \bar{\lambda}$, it optimally implements *cHmL*. In the latter case, an unconstrained optimal $\mathbf{w}^{ES2\_cHmL*}$ is possible, provided that the $[GT_k]$ constraint is not binding. If it is, then firm k selects a $\mathbf{w}^{GT}$ such that $\pi_{-k}^{ES2\_cHmL}|\mathbf{w}^{GT} = \pi_{-kHL}^{E*}$.

Finally, we point out that if firm $-k$ (the OEM buyer) is the Stackelberg leader, its optimal *ES2_cHmL* outcome is equal to the previous *ES2_cHL* outcome. This can be verified by checking that the OEM buyer experiences negative returns when $w_L > w_L^{ES2\_cHL*}$ and $w_H > w_H^{ES2\_cHL*}$.

A Firm Manufactures One Product; the Other Manufactures Two Products (*ES*1)**.** Suppose firm k is manufacturing just one product and the other firm $(-k)$ is manufacturing two products. By an argument similar to that in the proof of Observation 1, we conclude that a firm's outcomes in this *ES*1 scenario can be replicated by that firm's *ES*2 outcome with the proper setting of wholesale prices. Hence, the *ES*1 scenario is encompassed by the *ES*2 scenario.

Firms Produce One Differentiated Product Each (*ESS*)**.** Here we compute the outcomes when firms produce vertically differentiated products and act as suppliers to each other.

Scenario ESS_cHL. We start by considering the situation in which firms serve all consumers. When firm k supplies the low-quality product and firm $-k$ the high-quality product, the objective functions for the firms are

$$\pi_{kL}^{ESS} = (\bar{p}_k - w_H)\lambda\left(\frac{1}{2} - \frac{\bar{p}_k - \bar{p}_{-k}}{2t}\right) + \underline{p}_k(1-\lambda)\left(\frac{1}{2} - \frac{\underline{p}_k - \underline{p}_{-k}}{2t}\right) + w_L(1-\lambda)\left(\frac{1}{2} + \frac{\underline{p}_k - \underline{p}_{-k}}{2t}\right),$$

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

From the F.O.C.s, we can confirm that the optimal profits for the firms, conditional on $\mathbf{w}$, are

$$\pi_{kL}^{ESS\_cHL}|\mathbf{w} = \frac{t}{2} + (1-\lambda)w_L, \quad \pi_{-kL}^{ESS\_cHL}|\mathbf{w} = \frac{t}{2} + \lambda(w_H - c_{-kH}).$$

An argument similar to that for the *ES*2 case, finds that the wholesale prices that maximize profits for the firms are $w_L^{ESS\_cHL*} = w_L^{DD} \equiv v - 3t/2$ and $w_H^{ESS\_cHL*} = v + \bar{\theta}\Delta - t/2$. The ensuing outcomes for the firms will thus be

$$\pi_{kL}^{ESS\_cHL*} = (1-\lambda)v - (2-3\lambda)\frac{t}{2},$$

$$\pi_{-kH}^{ESS\_cHL*} = \lambda(v + \bar{\theta}\Delta - c_{kH}) + (1-3\lambda)\frac{t}{2}.$$

Scenario ESS_cHmL. Next we analyze outcomes when firms may ration out some of the low-type consumers. In this case, the objective function for the firms would be

$$\pi_{kL}^{ESS} = (\bar{p}_k - w_H)\lambda\left(\frac{1}{2} - \frac{\bar{p}_k - \bar{p}_{-k}}{2t}\right) + \underline{p}_k(1-\lambda)\left(\frac{v - \underline{p}_k}{t}\right) + w_L(1-\lambda)\left(\frac{v - \underline{p}_{-k}}{t}\right),$$

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

We maximize subject to the $[IC_{\bar\theta}]$ constraint to find the optimal prices conditional on $\mathbf{w}$:

$$\begin{aligned}
\underline{p}_{kL}^{ESS_cHmL}|\mathbf{w} &= [2v(4-\lambda)(1-\lambda)+2\lambda(1-\lambda)w_L \\
&\quad +(4-\lambda)\lambda(t-\bar\theta\Delta+w_H)]\cdot[(4-\lambda)(4-3\lambda)]^{-1},\\
\bar p_{kL}^{ESS_cHmL}|\mathbf{w} &= \bar\theta\Delta+\underline{p}_{k}^{ESS}|\mathbf{w},\\
\underline{p}_{-kH}^{ESS_cHmL}|\mathbf{w} &= [2v(4-\lambda)(1-\lambda)+4(2-\lambda)(1-\lambda)w_L \\
&\quad +(4-\lambda)(1-\lambda)(t-\bar\theta\Delta+w_H)] \\
&\quad \cdot[(4-\lambda)(4-3\lambda)]^{-1},\\
\bar p_{-kH}^{ESS_cHmL}|\mathbf{w} &= \bar\theta\Delta+\underline{p}_{-k}^{ESS}|\mathbf{w}.
\end{aligned}$$

The conditional profits $\pi_{kL}^{ESS\_cHmL}|\mathbf{w}$ and $\pi_{-kH}^{ESS\_cHmL}|\mathbf{w}$ are obtained by substituting the prices above in the original objective functions.

One can take derivatives with respect to $\mathbf{w}$ and substitute in the $\mathbf{w}^{ESS\_cHL*}$ wholesale prices to find that at this point

$$\frac{\partial(\pi_{kL}^{ESS\_cHmL}|\mathbf{w})}{\partial w_L}>0,\quad \frac{\partial(\pi_{kL}^{ESS\_cHmL}|\mathbf{w})}{\partial w_H}<0,$$
$$\frac{\partial(\pi_{-kH}^{ESS\_cHmL}|\mathbf{w})}{\partial w_L}<0,\quad \text{and}\quad \frac{\partial(\pi_{-kH}^{ESS\_cHmL}|\mathbf{w})}{\partial w_H}>0.$$

Continuity of the objective function allows us to conclude that if firm k, the producer of the low-quality product, is the Stackelberg leader, it wants to increase w_L and decrease w_H so as to extract more surplus from consumers and from firm $-k$. The existence of such a solution is possible because the $[IC_{\underline\theta}]$ constraint is not binding, which means that there exist $w_H<w_H^{ESS\_cHL*}$ and $w_L>w_L^{ESS\_cHL*}$ that still screen consumers. We call this outcome $\mathbf{w}^{cHmL*}$. This outcome ensues provided that the gains-from-trade constraint is not binding. If it is, then firm k selects a $\mathbf{w}^{GT}$ such that $\pi_{-kH}^{ESS\_cHmL}|\mathbf{w}=\pi_{-kHL}^{E*}$. As in the *ES*2 scenario, a game theoretical argument allows us to conclude that there is a $\bar\lambda$ such that the Stackelberg leader is indifferent between the *cHL* and *cHmL* outcomes and that firm k would like to serve all consumers when λ is small and ration out low-type consumers when λ is large.

If firm $-k$, the producer of the high-quality product, is the Stackelberg leader, it would not be able to improve on the outcomes it obtains when all consumers are served. The game theoretical argument is as follows: suppose that the firm is in the *cHmL* regime implementing off-equilibrium wholesale prices that are touching the *cHL* equilibrium scenario. If we ignore the $[IC_\theta]$ constraints we see that unconstrained profit for firm $-k$ decreases with w_L and increases with w_H. However, when we do observe the $[IC_\theta]$ constraints, we notice that $[IC_{\bar\theta}]$ is binding, thus preventing a decrease in w_L and/or a increase in w_H. Hence firm $-k$'s *cHmL* cannot improve upon the *cHL* outcome.

Analysis of the Initial Stage

When all consumers are being served (*cHL*), the comparison in outcomes is very straightforward. For the seller of both products in the *ES*2 regime, the *ES*2 outcome is better than the *ESS* outcome. Conversely, for the buyer of both products in the *ES*2 regime, the *ES*2 outcome is worse than the *ESS* outcome.

When consumers are being rationed out (*cHmL*), expressions are complex, and one may wonder whether both firms could prefer the same equilibrium outcome. The answer is no. The rationale is that the implementation of a $\mathbf{w}$ that rations out low-type consumers to extract more value from high-type consumers will naturally benefit more the OEM seller of both products (*ES*2 outcome) than the OEM seller of one product (*ESS* outcome). The converse is true for the OEM buyer.

Given the analysis above, we conclude that both the *ESS* and *ES*2 outcomes are feasible SPNE equilibria. If firms are in the *ES*2 SPNE, the seller of both products does not want to deviate to a different SPNE. By the same token, if firms are in the *ESS* SPNE, no firm wants to deviate to an *ES*2 outcome in which it is the buyer of both products. □

Appendix D. Proof of Proposition 3

Exogenous Product Lines—Analysis of the Second Stage

Outcomes for Entry Only (*E*)**.** Start by computing the outcomes when firms go to market independently. By using the demand expression from (1), we write the firms' profit expressions as

$$\pi_k^E=(p_k-c_k)\left(\frac12+\frac{[V(\theta,q_k)-V(\theta,q_{-k})]-(p_k-p_{-k})}{2t}\right).$$

By solving for the first-order conditions, we find that the optimal solution to this problem yields outcomes of $\pi_k^{E*}=\{3t+[V(\theta,q_k)-V(\theta,q_{-k})]-(c_k-c_{-k})\}^2/(18t)$. This implies that if firm k is producing a high-quality product,it accrues profit of $\pi_{kH}^{E*}=(3t+\theta\Delta-c_{kH})^2/(18t)$, whereas if firm k is producing a low-quality product, it obtains profit of $\pi_{kL}^{E*}=(3t-\theta\Delta+c_{-kH})^2/(18t)$.

Outcomes for OEM Combined with Entry (*ES*)**.** Consider first that the entrant is producing a high-quality product and selling it to the incumbent, which brings the product to the market. As it will become clear, the wholesale price w can induce different equilibrium regimes.

Scenario ES_c. If firms compete for consumers, the firms' profit expressions are

$$\pi_{iL}^{ES}=(p_i-w)\left(\frac12-\frac{p_i-p_e}{2t}\right),\tag{D1}$$

$$\pi_{eH}^{ES}=(p_e-c_{eH})\left(\frac12+\frac{p_i-p_e}{2t}\right)+(w-c_{eH})\left(\frac12-\frac{p_i-p_e}{2t}\right).\tag{D2}$$

It can be confirmed from the first-order conditions that the optimal solution to this problem yields outcomes of $\pi_{iH}^{ES\_c}|\,w=(3t+c_{eH})^2/(18t)$ and $\pi_{eH}^{ES\_c}|\,w=(3t-c_{eH})^2/(18t)+w$. Notice that $\partial(\pi_{iH}^{ES\_c}|\,w)/\partial w=0$ and $\partial(\pi_{eH}^{ES\_c}|\,w)/\partial w>0$, which enables the entrant to implement the highest wholesale price w such that firms still serve all consumers, which is $w=w^{DD}\equiv\theta(v+\Delta)-3t/2$, and firms end up in a touching competitive equilibrium. The ensuing outcomes for the firms are

$$\pi_{iH}^{ES\_c*}=\frac{t}{2}\quad\text{and}\quad\pi_{eH}^{ES\_c}|\,w=\theta(v+\Delta)-t-c_{eH}.$$

Scenario ES_m. Next consider that the wholesale price w is so high that firms end up becoming local monopolists.

In this case, we rewrite the firms' profit expressions as

$$\pi_{iL}^{ES} = (p_i - w)\frac{\theta(v+\Delta) - p_i}{t}, \tag{D3}$$

$$\pi_{eH}^{ES} = (p_e - c_{eH})\frac{\theta(v+\Delta) - p_e}{t} + (w - c_{eH})\frac{\theta(v+\Delta) - p_i}{t}. \tag{D4}$$

In this equilibrium regime, the firms' optimal profits as a function of w are

$$\pi_{iH}^{ES\_m} \mid w = \frac{[\theta(v+\Delta) - w]^2}{4t} \quad \text{and}$$

$$\pi_{eH}^{ES\_m} \mid w = \frac{[\theta(v+\Delta) - c_{eH}]^2 + 2[\theta(v+\Delta) - w][w - c_{eH}]}{4t}.$$

With respect to the incumbent's outcome, notice that $\partial(\pi_{iH}^{ES\_m} \mid w)/\partial w < 0$ (unless $w > \theta(v+\Delta)$, which is impossible because it makes the wholesale price greater than the maximum value of the product). By continuity of $\pi_{iH}^{ES\_m} \mid w$, we also notice that there is a w^{GT} that solves $\pi_{iH}^{ES\_m} \mid w \geq \pi_i^{E*}$ with equality.

With respect to the entrant's outcome, we find that there exist a $w^{FOC} \equiv [\theta(v+\Delta) + c_{eH}]/2$ such that $\partial(\pi_{eH}^{ES\_m})/\partial w > 0$ when $w < w^{FOC}$, and conversely $\partial(\pi_{eH}^{ES\_m})/\partial w < 0$ when $w > w^{FOC}$.

Finally, notice that if the entrant is producing a low-quality product, the *ES* equilibrium cannot be sustained because the incumbent finds it better to serve the market with its own high-quality product.

Outcomes for Supply Only (*S*)**.** Supply only cannot be an equilibrium because the entrant can always increase profit by selling to those consumers who locally prefer its brand.

Exogenous Product Lines—Analysis of the First Stage

Given the outcomes above, if the entrant produces a low-quality product, then its optimal strategy is entry only. On the other hand, if the entrant produces a high-quality product, then its optimal strategy is to enter the market and also to supply its product to the incumbent. If the incumbent is the Stackelberg leader, it proposes to buy the product at a price $w_i^* = w^{DD}$. On the other hand, if the entrant is the Stackelberg leader, it proposes to sell the OEM product at a price $w_e^* = \max\{w^{FOC}, w^{GT}\}$, where w^{GT} solves $\pi_i^{ES} \mid w^{GT} = \pi_i^{E*}$ with equality.

Endogenous Product Lines—Analysis of the Final Stage

Outcomes for Entry Only (*E*)**.** Because there is only one segment of consumers, there is no reason for a firm to bring two products to the market; hence, the general expression for entry-only outcomes is as in the exogenous case: $\pi_k^{E*} = \{3t + [V(\theta, q_k) - V(\theta, q_{-k})] - (c_k - c_{-k})\}^2/(18t)$.

If both firms produce a low-quality product, their outcome would be $\pi_k^{E\_LL} = t/2$.

If firm k is producing a high-quality product and the other firm ($-k$) produces a low-quality product, outcomes would be $\pi_{kH}^{E\_HL} = (3t + \theta\Delta - c_{kH})^2/(18t)$ and $\pi_{-kL}^{E\_HL} = (3t - \theta\Delta + c_{kH})^2/(18t)$.

If both firms produce a high-quality product, their outcomes would be $\pi_{kH}^{E\_HH} = [3t - (c_k - c_{-k})]^2/(18t)$.

The only possible equilibrium in this scenario is for both firms to produce high-quality products because $\theta\Delta > c_{kH}$; consequently, any firm producing a low-quality product would prefer to deviate to producing a high-quality product. Thus, the entry-only outcome is $\pi_{kH}^{E\_HH}$.

Outcomes for OEM Combined with Entry (*ES*)**.** The derivation for the outcomes for OEM combined with entry is very similar to those in the exogenous case. The objective functions for the firms in the competitive scenario are exactly as those in expressions (*D1*) and (*D2*). By the same token, in the endogenous local monopolistic scenarios the objective functions are exactly as those in expressions (*D3*) and (*D4*).

The only difference in the derivation of the outcomes is that in the gains-from-trade constraint, the buyer's outside option always involve the entry-only outcome of producing a high-quality product $\pi_{kH}^{E\_HH}$. Thus, if firm k is the buyer, w^{GT} solves $\pi_{kH}^{ES\_m} \mid w^{GT} = \pi_{kH}^{E\_HH}$.

Finally, notice that an *ES* arrangement in which the buyer sources a low-quality product cannot be sustained because the buyer finds it better to serve the market with its own high-quality product.

Outcomes for Supply Only (*S*)**.** Supply only cannot be an equilibrium because the entrant can always increase profit by selling to those consumers who locally prefer its brand.

Endogenous Product Lines—Analysis of the Initial Stages

Given the outcomes above, the only possible SPNE equilibrium is an entry-and-supply arrangement in which the low-cost manufacturer of the high-quality product supplies it to the other firm.

If the incumbent is the Stackelberg leader, it proposes to buy the product at a price $w^* = w^{DD} \equiv \theta(v+\Delta) - 3t/2$ and a touching equilibrium configuration emerges. On the other hand, if the entrant is the Stackelberg leader, it proposes to sell the OEM product at a price $w^* = \max\{w^{FOC}, w^{GT}\}$.

Remark—No Vertical Differentiation

By inspecting the results above, we can also determine the outcomes in case firms had the same product line.

If both firms were producing a low-quality product, the entry-only outcomes for the firms would be $\pi_k^{E*} = t/2$. OEM combined with entry would not improve the outcomes for the buyer; thus, the ensuing equilibrium would be entry only.

If both firms were producing a high-quality product, then the profit outcomes would be as in the endogenous product lines case: the entry-only outcomes for the firms would be $\pi_k^{E*} = [3t - (c_k - c_{-k})]^2/(18t)$, but firms can do better by engaging in an OEM and supply arrangement in which the low-cost producer of the high-quality product sells it to the high-cost producer. This implies that a low-cost entrant will enter the market and sell the product to the incumbent. Similarly, when firms can sell to each other, the entrant will enter the market and the low-cost producer will sell the product to the high-cost producer. □

Appendix E. Proof of Proposition 4

Exogenous Product Lines—Analysis of the Second Stage

Outcomes for Entry Only (E)**.** There is no pure-strategy Nash equilibrium for entry only. To see this, consider the following. If the low-quality firm pursues low-type 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 high-type 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 $p_{kH}^{\text{indif}} \equiv [\lambda/(1-\lambda)](\bar{\theta}-1)\Delta + c_{kH}$ as the minimum price the high-quality firm is willing to set so as to compete for low-type consumers. Similarly, we define $p_{kL}^{\text{indif}} \equiv [(1-\lambda)/\lambda](\bar{\theta}-1)\Delta + c_{kL}$ as the minimum price the low-quality firm is willing to set so as to compete for high-type consumers.

For the high-quality firm, a price $p_{kH} > p_{kH}^{\text{indif}}$ cannot be an equilibrium because the firm is able to lower its price to capture low-type 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 high-type consumers only and set the price $p_{kH} = \min\{p_{kH}^{\text{indif}} + (\bar{\theta}-1)\Delta,\ v+\bar{\theta}\Delta\}$. This, in turn, allows the low-quality firm to increase its price to just below $p_{kL} = \min\{p_i^{\text{indif}} + (\bar{\theta}-2)\Delta,\ v\}$. Such a move by the low-quality firm reignites the price competition for high-type consumers. By the same rationale, any low-quality firm price $p_{kL} > p_{kL}^{\text{indif}}$ cannot be an equilibrium because if the low-quality firm sets a price $p_{kL} < p_{kH} - \bar{\theta}\Delta$, to capture all consumers, the high-quality firm can set a price $p_{kH} = p_{kL} + \bar{\theta}\Delta$ to recapture high-type consumers. Firms can undercut each other in this fashion up to the point at which $p_{kL} < p_{kL}^{\text{indif}}$, 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 $p_{kH}^{\text{indif}} < p_{kL}^{\text{indif}}$ or $p_{kH}^{\text{indif}} < p_{kL}^{\text{indif}}$. We define $\bar{\lambda} \equiv (c_{kH} + (2\bar{\theta}-1)\Delta - [(c_{kH}-\Delta)^2 - 4\bar{\theta}\Delta^2 + 4\bar{\theta}^2\Delta^2]^{1/2}/(2c_{kH})$, and notice that because $p_{kH}^{\text{indif}} = [\lambda/(1-\lambda)](\bar{\theta}-1)\Delta + c_{kH}$, and $p_{kL}^{\text{indif}} = [(1-\lambda)/\lambda]\cdot(\theta-1)\Delta$, then $\lambda < \bar{\lambda} \Rightarrow p_{kH}^{\text{indif}} < p_{kL}^{\text{indif}}$, and $\lambda > \bar{\lambda} \Rightarrow p_{kH}^{\text{indif}} > p_{kL}^{\text{indif}}$.

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 $p_{kH}^{\text{indif}} - \Delta$. Furthermore, given that if the other firm deviates to serve only high-type consumers, it optimally does so by charging $p_{kH}^{\text{indif}} + (\bar{\theta}-1)\Delta$, the low-quality firm never prices above $p_{kH}^{\text{indif}} + (\bar{\theta}-2)\Delta$ because doing so means that it captures no consumers. The lower-bound constraint in the price-density function of the low-quality firm is its own marginal cost (i.e., 0) and the upper bound is the maximum price it sets when pursuing low-type consumers (i.e., v). Consequently, the support of $F_{kL}[p]$ is the range $[\max\{p_{kH}^{\text{indif}} - \Delta, 0\},\ \min\{p_{kH}^{\text{indif}} + (\bar{\theta}-2)\Delta,\ v\}]$.

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

$$\begin{aligned}\pi_{kH}^{\text{entry}} &= (1-\lambda)(p_{kH}-c_{kH})(1-F_{kL}[p_{kH}-\Delta]) \\ &\quad + \lambda[p_{kH} + (\bar{\theta}-1)\Delta - c_{kH}] \\ &\quad \cdot (1-F_{kL}[p_{kH}-\Delta]) = \zeta, \end{aligned} \tag{E1}$$

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 low-type consumers (when $p_{kH} < p_{kL} - \Delta$), and 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 high-type consumers (when $p_{kH} < p_{kL} - \bar{\theta}\Delta$). Given the density support, we can determine that $F_{kL}[p_{kH}^{\text{indif}} - \Delta] = 0$. Furthermore, by replacing p_{kH} and p_{kL} with p and solving equation (E1) for $F_{kL}[p-\Delta]$ we obtain $F_{kL}[p-\Delta] = 1 - \zeta/[p - c_{kH} + \lambda(\bar{\theta}-1)\Delta]$.

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

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

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

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

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

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

$$\underline{\pi}_{kH}^E = \frac{1-\lambda+(2\lambda-\lambda^2)(\bar{\theta}-1)}{1-\lambda}\Delta,$$

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

For the situation in which $\lambda > \bar{\lambda}$, one follows the 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

$$\bar{\pi}_{kH}^E = (\bar{\theta}\Delta - c_{kH}) + \frac{(1-\lambda)^2(\bar{\theta}-1)\Delta}{\lambda},$$

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

Outcomes for Supply Only (S)**.** The proof for the supply-only outcomes follows a traditional gains-from-trade proof.

If the entrant stays out of the market and sells its product to the incumbent, then the incumbent can extract the maximum revenue from consumers by charging $\underline{p}_i = v$ 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 $\pi_i^S \mid w + \pi_e^S \mid w \geq \pi_i^E + \pi_e^E$, where $\pi_k^S \mid w$ is the supply-only outcome and π_k^E is the entry-only outcome previously computed.

Because in the OEM-supply-only firms do not compete, it is direct to conclude that $(\partial \pi_i^S \mid w)/\partial w < 0$ and $(\partial \pi_e^S \mid w)/\partial w > 0$. Therefore, if the incumbent is the Stackelberg leader, it offers to buy the OEM product at the lowest price w^* that respects the constraint that $\pi_e^S \mid w \geq \pi_e^E$. Conversely, if the entrant is the Stackelberg leader, it offers to sell the OEM product at a price w^* such that $\pi_i^S \mid w \geq \pi_i^E$.

Outcomes for OEM Combined with Entry (*ES*)**.** 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. Finally, 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).

Exogenous Product Lines—Analysis of the First Stage

Given the outcomes computed above, the entrant's optimal strategy is OEM supply 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 (*S*) outcome derived above.

Endogenous Product Lines

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 $\pi_i^M = \lambda(v + \bar{\theta}\Delta - c_{iH}) + (1-\lambda)v$. Also notice, in the claim below, that the entrant will not enter the market with the low-quality product.

Claim 2. *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 high-type 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 high-type 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. Because of the reasoning in Claim 2, 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, 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 2 to argue that it is not profitable for the entrant to enter the market on its own. Furthermore, it is not beneficial for the incumbent to buy the product from the entrant; thus, we rule out an OEM arrangement.

On the other hand, if $c_{iH} > c_{eH}$, the entrant can enter the market and earn profit. The entrant can price the high-quality product at $\bar{p}_e = c_{iH} - \varepsilon$ and capture not only all high-type consumers but also all low-type consumers, because $\Delta > c_{kH}$. However, if the entrant stays out of the market and supplies the product to the incumbent, then the latter can extract monopolistic revenues from consumers (i.e., charge $\bar{p}_i^S = v + \bar{\theta}\Delta$, $\underline{p}_i^S = v$). Consequently, there is a wholesale price $w_H \in (c_{eH}, c_{eH})$ for the high-quality product such that and OEM relationship is Pareto improving for the firms.

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

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

Theses are direct functions of w_H. Therefore, if the incumbent is the Stackelberg leader, it offers to buy the entrant's high-quality product at the lowest price w_H^* that respects the gains-from-trade constraint. Conversely, if the entrant is the Stackelberg leader, it offers to sell the OEM product at the highest price w_H^* that respects the gains-from-trade constraint. □

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