Demand-Investment in Distribution Channels

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Abstract

We study a manufacturer's demand-investment decisions in distribution channels subject to double marginalization. Casting this as a mechanism design problem, we show that demand-enhancing investments strengthen retailers' incentives to exploit market power, forcing manufacturers to concede greater rents. Manufacturers therefore optimally restrict product quality or market coverage. We fully characterize which demand parameters create these perverse incentives: increases benefit manufacturers in segments where they control pricing but harm them in segments with binding incentive constraints. This reveals fundamental limits to demand-side investment in vertical relationships.

JEL Classification:D21, D82, L11

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In modern markets, manufacturers typically rely on independent intermediaries to reach final users. In consumer goods, supermarkets link producers and customers, while in digital markets, platforms such as Amazon and eBay play a similar role. In services, hotels and property owners depend on Booking.com and Airbnb, and in software, developers rely on app stores operated by Apple and Google. Across sectors, this institutional separation shapes both market outcomes and firm strategies.

Understanding manufacturers' investment incentives in such settings is essential, particularly when both manufacturers and retailers have market power that may lead to

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distortions. The allocation of pricing power and the structure of the distribution channel determine how investments—whether in product quality, marketing, or, more broadly, market demand—translate into profits. Strategic interactions within the channel over control and surplus division generate investment distortions that fundamentally depend on the demand structure.

A foundational model for analyzing these issues is Spengler (1950), who introduced the problem of double marginalization in vertical markets. In this model, independent pricing decisions by manufacturers and retailers lead to higher consumer prices, lower total surplus, and suboptimal levels of market activity. While this logic is well understood in the context of pricing, its implications for manufacturer investments—particularly those aimed at influencing market demand—have received less attention.

By casting the double marginalization problem as one of mechanism design, we fully characterize the manufacturer's investment incentives to influence demand. Our approach characterizes how manufacturers design contracts to control retailers' pricing decisions rather than to price discriminate. This identifies which segments of demand actually govern investment decisions—an increase in demand has a positive effect at the equilibrium price, and a negative effect at prices where incentive constraints bind, whereas it has no effect elsewhere. This level of insight is unobtainable when using a smooth parametric analysis, as its implicit continuous optimization obscures these critical points.

Contrary to the standard view, which takes the benefits of expanding demand for granted, we show that double marginalization can create perverse incentives—manufacturers may benefit from lowering product quality or deliberately restricting appeal to certain consumer groups. Our analysis thus highlights new distortions and strategic trade-offs in vertical relationships, contributing to microeconomic theory by revealing inherent limits to demand-side investment and deepening our understanding of distribution channels.

The intuition for this result is straightforward—increasing demand or product quality strengthens the retailer's incentive to exploit its market power toward consumers, compelling the manufacturer to cede greater rents. To mitigate this effect, the manufacturer may find it optimal to limit product quality or restrict market access to dampen the retailer's incentive to exploit its market power. The mechanism design framework formalizes this intuition by explicitly characterizing the incentive compatibility constraints that drive these outcomes, distinguishing market environments in which such perverse incentives emerge from those where demand expansion remains unambiguously desirable.

Our theoretical predictions align with empirical observations. Manufacturers often distribute higher- or lower-quality products through retailers compared to direct sales. For example, Lawton (2007) reports in the Wall Street Journal that many PC manufacturers supply their higher-quality lines exclusively through selected retailers. Conversely, some budget products are distributed solely via retail channels. As Kissell (2022) notes in MoneyTalkNews, based on industry interviews, companies frequently produce distinct models for distributors such as Walmart to accommodate pricing requirements. These observations are broadly consistent with the prediction that a manufacturer's choice of distribution channel is intertwined with its quality decisions.

The literature in industrial organization views Spengler (1950)'s double marginalization problem as foundational, serving as the canonical textbook starting point for analyzing vertical relationships (Tirole, 1988). The problem has also been instrumental in shaping antitrust policy toward vertical integration and vertical restraints. Yet, despite its prominence, the literature lacks a systematic analysis of how the double marginalization problem affects the manufacturer's incentives in demand-side investments.[1]

The literature has instead focused on other aspects of vertical relationships. Seminal studies such as Mathewson and Winter (1984), Rey and Tirole (1986), and Bolton and Bonanno (1988) broadened Spengler's analysis by contrasting double marginalization with additional sources of inefficiency. Recent work emphasizes informational frictions: Janssen and Shelegia (2015) show that unobservable wholesale prices amplify double marginalization, while Loertscher and Marx (2022) and Choné et al. (2023) argue that double marginalization results from asymmetric information rather than the use of linear wholesale prices. Empirical work confirms the relevance of double marginalization. Villas-Boas (2007) documents that retailers retain substantial downstream pricing power even when wholesale prices approach marginal cost, establishing double marginalization as a robust phenomenon.

Uncovering perverse investment incentives, our paper is also related to studies on "damaging goods" and "demarketing." Deneckere and McAfee (1996) show that manufacturers may deliberately damage products to better engage in second-degree price discrimination when consumer preferences are private information. Miklós-Thal and Zhang (2013) demonstrate that when manufacturers have private information about product qualities, demarketing mitigates buyers' quality concerns. Relatedly, Kim and Shin (2014) argue that demarketing creates buyers' countervailing incentives that facilitate price discrimination. Like these studies, ours also highlights the manufacturer's incentive to hinder market demand. The reasoning in our paper, however, is different—the manufacturer constrains demand to alleviate incentive problems arising from double marginalization in the distribution channel.

[1]Closest is Dellarocas (2012), who studies the investment incentives of online advertising platforms that use pay-per-action schemes which lead to double marginalization.

The remainder of the paper is organized as follows. Section 2 presents the base setup and analysis, discussing the effect of changes in demand on the manufacturer's profit in the presence of double marginalization. Section 3 discusses the implications of our findings in Section 2. Section 4 extends our results to different types and forms of changes in demand. Section 5 concludes. All proofs are provided in the Appendix.

1 Setup and Basic Analysis

A manufacturer (M) lacks its own distribution network and relies on a retailer (R) to sell to final consumers. M produces at zero cost and offers the product to R at wholesale price $w \in \mathbb{R}_+$. Observing w, R sets retail price $p \in \mathbb{R}_+$.[2] Demand is $q = D(p)$. M's and R's profits are

$$\Pi^M(w,p) \equiv wD(p) \text{ and } \Pi^R(w,p) \equiv (p-w)D(p).$$

We study M's incentives to invest in demand in this classic double marginalization setting. We obtain the counterintuitive insight that M may benefit from *reducing* certain aspects of demand when selling through R. We identify the exact conditions under which this happens and use a mechanism design perspective to explain how this insight is linked to the double marginalization problem.

Two Consumer Groups

To demonstrate our result and intuition most clearly, we first consider the special case of two consumer groups with valuations $v_1 > v_2$. Group i contains $\tilde{n}_i$ consumers, each with unit demand. Define $n_1 \equiv \tilde{n}_1$ and $n_2 \equiv \tilde{n}_1 + \tilde{n}_2$ as cumulative quantities. The demand function (Panel (a) in Figure 1) is:

$$D(p) = \begin{cases} n_2 & \text{if } p \leq v_2 \\ n_1 & \text{if } p \in (v_2, v_1] \\ 0 & \text{otherwise.} \end{cases}$$

Demonstrating double marginalization in this sequential game between M and R is straightforward. R rejects any $w > v_1$ and chooses $p \in \{v_1, v_2\}$ for $w \leq v_1$, selecting between profit levels $\Pi^R_1 = (v_1 - w)n_1$ and $\Pi^R_2 = (v_2 - w)n_2$. Define:

$$w_{12} \equiv \frac{n_2 v_2 - n_1 v_1}{n_2 - n_1} < v_2. \tag{1}$$

[2] While platforms like Amazon or Airbnb charge percentage fees rather than set prices, these modeling approaches are strategically equivalent. Setting a retail price p is equivalent to responding to wholesale price w with markup $(1+\pi)$, where $p = (1+\pi)w$. We use the price-setting formulation as it is standard in the double marginalization literature.

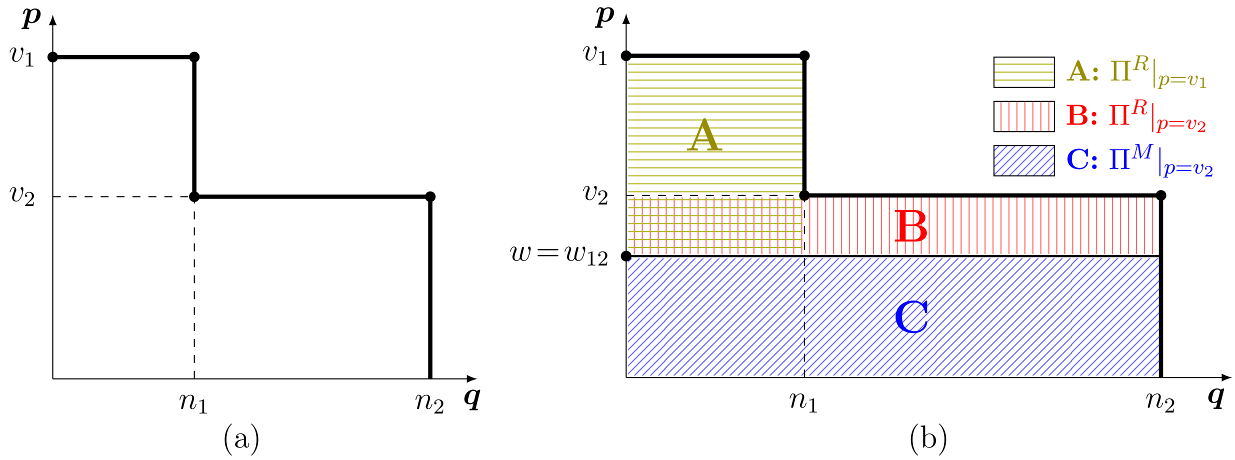

Figure 1: Two consumer groups $(v_1, v_2; n_1, n_2)$.

For $w \geq w_{12}$, R's best response is $p = v_1$; for $w \leq w_{12}$, it is $p = v_2$.

If M wants $p = v_1$, the optimal wholesale price is $w = v_1$. M extracts all surplus, and $\Pi_1^M = v_1 n_1$. If M wants $p = v_2$, it must leave R a rent. M sets $w = w_{12}$ (any higher price induces $p = v_1$), yielding profit $\Pi_2^M = w_{12} n_2$ and leaving R rent $\bar{\Pi}_2^R = (v_2 - w_{12}) n_2 > 0$.

This rent captured by R leads to the comparative statics that M's profits are decreasing in both v_1 and n_1:

$$\frac{d\Pi_2^M}{dv_1} = \frac{\partial \Pi_2^M}{\partial w_{12}} \frac{\partial w_{12}}{\partial v_1} = n_2 \frac{-(n_2 - n_1) v_2}{(v_1 - v_2)^2} < 0 \quad \text{and} \quad \frac{d\Pi_2^M}{dn_1} = \frac{\partial \Pi_2^M}{\partial w_{12}} \frac{\partial w_{12}}{\partial n_1} = n_2 \frac{-v_1}{(v_1 - v_2)^2} < 0.$$

Hence, M benefits from lowering v_1, the valuation of high-valuation consumers, and from lowering n_1, the number of consumers who value the good at v_1 rather than v_2. This effect stems from $\partial w_{12}/\partial v_1 < 0$ and $\partial w_{12}/\partial n_1 < 0$: as v_1 or n_1 increases, M must leave R a larger rent to maintain price $p = v_2$, even though the revenue $v_2 n_2$ at this price remains unchanged.

Panel (b) in Figure 1 illustrates this mechanism. The threshold w_{12} equates areas A and B, leaving area C as M's profit Π_2^M when R sets $p = v_2$. Raising v_1 or n_1 increases area A while keeping area B constant, if M keeps the wholesale price unchanged. Hence, R now picks $p = v_1$ rather than $p = v_2$. To restore $p = v_2$ as R's best response, M must lower the wholesale price w. This decrease in w raises area B more than area A, but reduces area C, thereby lowering M's profit.

Arbitrarily Many Consumer Groups

We generalize to $k \in \mathbb{N}$ consumer groups with decreasing valuations v_i, where $i \in I \equiv \{1, \ldots, k\}$. Let n_i denote the number of consumers with valuation at least v_i. The k

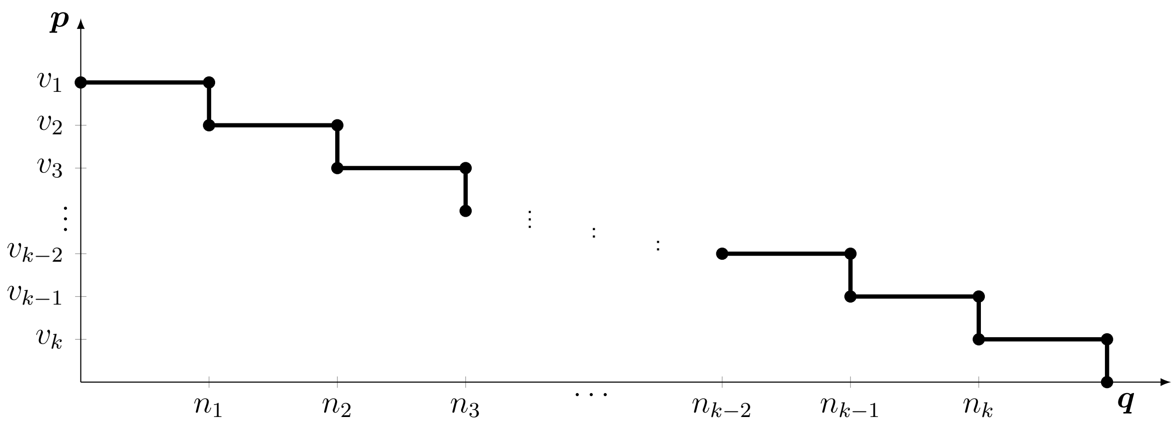

Figure 2: Demand with k consumer groups

groups are fully described by the $2k$-dimensional parameter vector:

$$\varphi = \{v_1, \dots, v_k; n_1, \dots, n_k\}.$$

Using $v_{k+1} = 0$, the demand function $D(p|\varphi)$ is

$$D(p|\varphi) = \begin{cases} n_i & \text{if } p \in (v_{i+1}, v_i] \\ 0 & \text{otherwise.} \end{cases}$$

Figure 2 illustrates this demand structure.

Since M and R choose wholesale price w and retail price p sequentially, we can solve the game by backward induction to obtain the equilibrium characterization:

$$\hat{p}(w) \in \arg\max_p (p - w)D(p|\varphi) \quad \text{and} \quad \hat{w} \in \arg\max_w wD(\hat{p}(w)|\varphi) \tag{2}$$

with corresponding equilibrium payoffs:

$$\hat{\Pi}^R = \Pi^R(\hat{p}(w), \hat{w}) \quad \text{and} \quad \hat{\Pi}^M = \Pi^M(\hat{p}(w), \hat{w}). \tag{3}$$

While this compactly represents the equilibrium outcome, it does not reveal the comparative statics of changes in the demand parameters φ.

To unpack the comparative statics, we adopt a mechanism-design approach that transforms the sequential game into an incentive problem—identifying the wholesale price w that induces R to set a given retail price p. We say that a retail price p is *incentive compatible at wholesale price* w if:

$$\Pi^R(w, p) \geq \Pi^R(w, p') \text{ for all } p' \in \mathbb{R}. \tag{4}$$

That is, p is *incentive compatible* if there exists a w that satisfies (4). Moreover, we say that p is *individually rational at wholesale price* w if and only if:

$$\Pi^R(w, p) \geq 0. \tag{5}$$

Together, a pair (w, p) is *feasible* if p is incentive compatible at w and individual rational—in other words, (w, p) is feasible if and only if p is a best response to w.

Defining the thresholds analogous to w_{12} in (1):

$$w_{ij} \equiv \frac{v_i n_i - v_j n_j}{n_i - n_j} \tag{6}$$

and also:

$$\underline{w}_i \equiv \begin{cases} \max\{w_{ij} \mid j > i\} & \text{if } i < k \\ 0 & \text{if } i = k \end{cases} \quad \text{and} \quad \overline{w}_i \equiv \begin{cases} \min\{w_{ij} \mid j < i\} & \text{if } i > 1 \\ v_1 & \text{if } i = 1 \end{cases}, \tag{7}$$

we obtain the following characterization of feasibility.

Lemma 1 *A pair (w, p) is feasible if and only if there is an $i \in I$ such that $p = v_i$ and*

$$w \in [\underline{w}_i, \overline{w}_i]. \tag{8}$$

Intuitively, condition (8) ensures that $p = v_i$ is R's best response to w. A retail price p is *implementable* if there is a wholesale price w so that (w, p) is feasible. Lemma 1 then directly implies that retail price $p = v_i$ with $i \in I$ is implementable if and only if:

$$i \in \mathcal{I} \equiv \{i \in I | \overline{w}_i \geq \underline{w}_i\}. \tag{9}$$

Having characterized feasibility in Lemma 1, we now characterize optimality in the next lemma. We first identify M's optimal wholesale price that implements a retail price $p = v_i$ with $i \in \mathcal{I}$ in (9). We then identify the retail price $p = v_{\hat{\imath}}$ that M considers optimal to implement.

Lemma 2 *M's profit-maximizing wholesale price w that induces $p = v_i$ with $i \in \mathcal{I}$ is $\hat{w}_i \equiv \overline{w}_i$. M optimally induces $i = \hat{\imath}$ where $\hat{\imath} = \arg\max_{i \in \mathcal{I}} \overline{w}_i n_i$, yielding profits $\hat{\Pi}^M \equiv \overline{w}_{\hat{\imath}} n_{\hat{\imath}}$ to M and profits $\hat{\Pi}^R \equiv (v_{\hat{\imath}} - \overline{w}_{\hat{\imath}}) n_{\hat{\imath}}$ to R.*

Lemma 2 provides a full characterization of the equilibrium outcome of the sequential game between the manufacturer and the retailer, offering an alternative to the backward induction characterization in (2) and (3).

As mentioned above, the advantage of this approach is that it allows us to assess the effect of changes in a demand parameter in φ on M's profit $\hat{\Pi}^M$ through the set of $j \in I$ that constrain M at the optimum:

$$\mathcal{J} \equiv \{j \in I \mid \overline{w}_{\hat{\imath}} = w_{\hat{\imath}j}\}. \tag{10}$$

In general, there can be multiple binding incentive constraints, so $\mathcal{J}$ may contain more than one element.[3]

Based on the set $\mathcal{J}$, the next theorem fully describes the comparative statics of changes in any of the demand parameters $\varphi = \{v_1, \ldots, v_k; n_1, \ldots, n_k\}$.

Theorem 1 *M's optimal profit $\hat{\Pi}^M$ exhibits the following comparative statics in $\varphi = \{v_1, \ldots, v_k; n_1, \ldots, n_k\}$:*

- *For $\hat{\imath} \in I$:*
$$\frac{\partial \hat{\Pi}^M}{\partial v_{\hat{\imath}}} > 0, \frac{\partial \hat{\Pi}^M}{\partial n_{\hat{\imath}}} > 0.$$
- *For $j \notin \mathcal{J}$:*
$$\frac{\partial \hat{\Pi}^M}{\partial v_j} = \frac{\partial \hat{\Pi}^M}{\partial n_j} = 0.$$
- *For $j \in \mathcal{J}$ and $|\mathcal{J}| = 1$:*
$$\frac{\partial \hat{\Pi}^M}{\partial v_j} < 0; \ \frac{\partial \hat{\Pi}^M}{\partial n_j} < 0.$$
- *For $j \in \mathcal{J}$ and $|\mathcal{J}| > 1$:*
$$\frac{\partial \hat{\Pi}^M}{\partial^+ v_j} < 0; \ \frac{\partial \hat{\Pi}^M}{\partial^+ n_j} < 0; \ \frac{\partial \hat{\Pi}^M}{\partial^- v_j} = 0; \ \frac{\partial \hat{\Pi}^M}{\partial^- n_j} = 0,$$
where ∂/∂^+ and ∂/∂^- are directional comparative statics for increasing and decreasing the parameter respectively.

Theorem 1 extends the case with two consumer groups to the general case with $k \in \mathbb{N}$ groups. The result thus confirms and generalizes our earlier finding—increases in certain demand parameters can decrease M's profit when distribution takes place through R.

The mechanism is straightforward. When M cannot dictate retail prices, it must leave rents to R to induce appropriate pricing in the market. Higher valuations or larger high-valuation consumer groups increase R's incentive to raise prices, forcing M to provide larger rents to R for keeping low prices in the market. As a result, increased demand, whether through higher product valuations or larger consumer groups, in segments with binding incentive constraints reduces M's profit.

2 Economic Implications

We discuss two direct implications of our results for M's strategic choices, focusing on demand management and distribution channel selection.

[3]While we cannot exclude this multiplicity in general, it occurs only for specific demand structures.

Demand Management

We endogenize the demand parameters by allowing M to alter demand through product improvement or marketing. To identify the underlying economic forces, it suffices to consider the two-consumer case where $\varphi = \{v_1, v_2; n_1, n_2\}$, assuming that M can affect v_1, the high-valuation, holding other parameters fixed.

From the analysis in Section 1, the optimal wholesale price that induces $p = v_i$ is:

$$w_i = \begin{cases} \frac{v_2 n_2 - v_1 n_1}{n_2 - n_1} & \text{for } i = 2 \\ v_1 & \text{for } i = 1 \end{cases} \quad \text{with} \quad \Pi_i^M = \begin{cases} \frac{v_2 n_2 - v_1 n_1}{n_2 - n_1} n_2 & \text{for } i = 2 \\ v_1 n_1 & \text{for } i = 1 \end{cases}. \tag{11}$$

By defining:

$$\hat{v} \equiv \frac{v_2 n_2^2}{n_1(2n_2 - n_1)},$$

it follows from comparing profits in (11) that optimal profits are:

$$\hat{\Pi}^M = \begin{cases} \frac{v_2 n_2 - v_1 n_1}{n_2 - n_1} n_2 & \text{for } v_1 < \hat{v} \\ v_1 n_1 & \text{for } v_1 \geq \hat{v}. \end{cases} \tag{12}$$

The corollary below directly follows.

Corollary 1 *Under retail distribution, $\hat{\Pi}^M$ is strictly decreasing in v_1 for $v_1 < \hat{v}$ and strictly increasing in v_1 for $v_1 > \hat{v}$.*

Panel (a) of Figure 3 illustrates M's optimal profit as a function of v_1. It illustrates that for $v_1 < \hat{v}$, M has a local incentive to decrease the demand by lowering product quality. Prior studies on *damaged goods* and *demarketing* examine these practices from a price discrimination perspective. Our analysis suggests these strategies may also alleviate double marginalization when selling through an intermediary.

Distribution Channel Selection

Up to this point, we have assumed that the manufacturer, M, can only distribute its product to consumers through a retailer, R. However, M may find it more attractive to build its own distribution network and cut out the middleman. By allowing M to invest in such a network and directly sell its product to consumers in the market, we endogenize M's choice between distribution channels—direct distribution versus retail distribution. The cost of the network investment to M is given by a fixed cost denoted by:

$$F \in (0, \overline{F}), \text{ where } \overline{F} = v_2 n_2 \left(1 - \frac{n_2}{2n_2 - n_1}\right) > 0.^4$$

[4]With $F < \overline{F}$, we bypass a trivial outcome with which using a retailer for distribution is always optimal. Similarly, if $F = 0$, then direct distribution is always optimal.

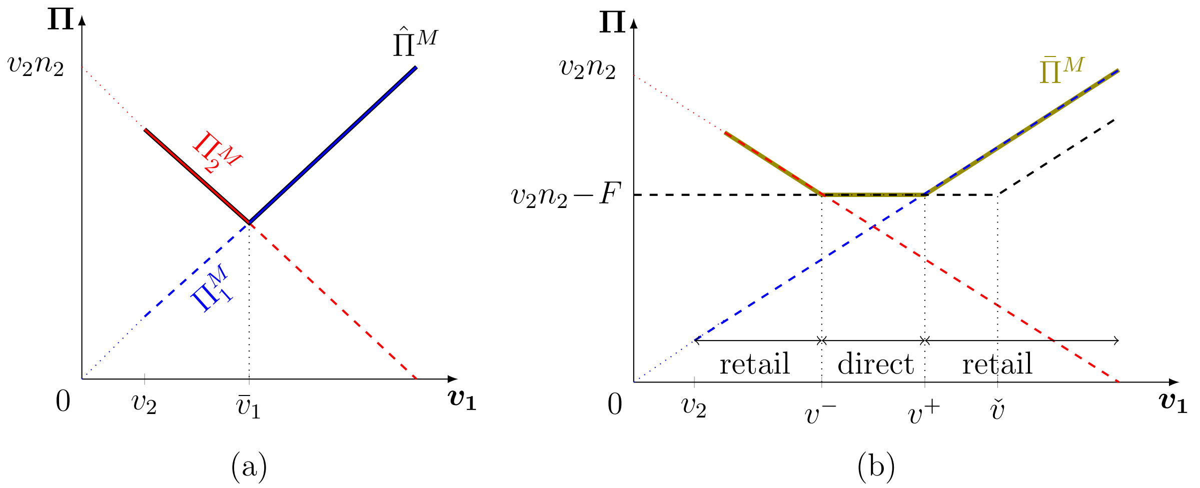

Figure 3: Panel (a) M's profits Π_1^M, Π_2^M, and $\hat{\Pi}^M$ as a function of v_1; Panel (b) M's optimal distribution choice: direct versus retail distribution

Under direct distribution, M's profit from charging $p = v_i$ is:

$$\Pi_i^M = v_i n_i - F.$$

Defining

$$\check{v} \equiv \frac{v_2 n_2}{n_1},$$

M's optimal profit under direct distribution, denoted by $\check{\Pi}^M$, is:

$$\check{\Pi}^M = \begin{cases} v_2 n_2 - F & \text{if } v_1 \leq \check{v} \\ v_1 n_1 - F & \text{if } v_1 > \check{v} \end{cases} \tag{13}$$

Combining M's optimal profits under direct and retail distribution, M's profit when it can choose the distribution channel is given by:

$$\overline{\Pi}^M = \max\{\hat{\Pi}^M, \check{\Pi}^M\}.$$

Corollary 2 *There exist $v^- < v^+$, where $v^- < \hat{v}$ and $v^+ \in (\hat{v}, \check{v})$, such that:*

- *For $v_1 \leq v^-$, M chooses retail distribution.*
- *For $v_1 \in (v^-, v^+)$, M chooses direct distribution.*
- *For $v_1 \geq v^+$, M chooses retail distribution.*

Panel (b) of Figure 3 illustrates M's optimal profit and distribution channels as a function of the product's high-valuation v_1.

As pointed out in the introduction, manufacturers often distribute higher- or lower-quality products through retailers compared to direct sales (Lawton, 2007; Kissell, 2022). To see how such observations emerge when manufacturers jointly optimize channel and quality choices, consider the following extension of the double marginalization game: (1) Demand $\varphi = (v_1, v_2, n_1, n_2)$ is publicly observed. (2) M chooses between direct and retail distribution. (3) M adjusts demand parameter v_1 marginally. (4) If M chose retail distribution, the double marginalization game is played; if M chose direct distribution, M sets price directly.

From Corollary 1 and 2, it directly follows that M has incentives to adjust the demand by changing v_1 only when it chooses to use retail distribution—decreasing it when v_1 is low and increasing it when v_1 is high. Panel (b) of Figure 3 illustrates this result. For small v_1, profit $\overline{\Pi}^M$ decreases. For intermediate v_1, where M chooses direct distribution, $\overline{\Pi}^M$ remains constant. For large v_1, $\overline{\Pi}^M$ increases.

3 Extended Analysis

To fully identify the extent to which the double marginalization problem affects the manufacturer's incentives for investing in demand, we further extend the basic analysis from Section 1. We first discuss the case in which M's investment affects multiple demand segments simultaneously. Second, we show how this analysis extends to smooth demand functions.

Changes in Multiple Segments

In Theorem 1, we treated each demand parameter separately. That is, only one segment of the demand curve changes. We did this intentionally to identify which demand segments affect M's profit and how. However, M's investments may in general lead to changes across multiple segments simultaneously. We now analyze this more general case.

The extension models demand as a function of a one-dimensional parameter $\delta \in \mathbb{R}$:

$$\varphi(\delta) = \{v_1(\delta), \ldots, v_k(\delta); n_1(\delta), \ldots, n_k(\delta)\}, \tag{14}$$

where each v_i and each n_i is a function of δ. As a result, M's profit is $\hat{\Pi}^M(\delta)$ and its comparative statics are obtained by assessing $\partial\hat{\Pi}^M(\delta)/\partial\delta$.

As an illustration, consider a specification that discretizes a linear demand function in $k+1$ steps:

$$v_i(\delta) = \frac{k+1-i}{k+1}\delta \quad \text{and} \quad n_i(\delta) = \frac{i}{k+1},$$

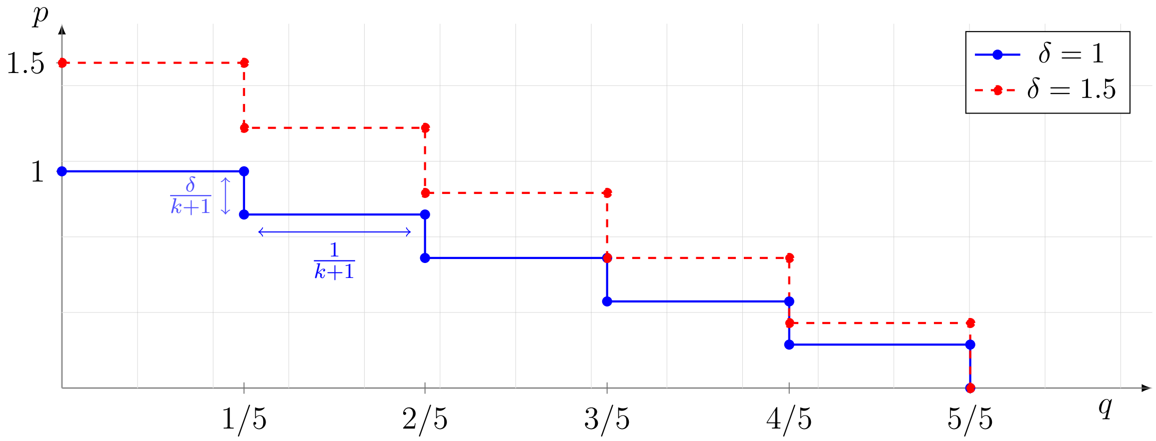

Figure 4: Demand function $D(p|\varphi(\delta))$ with $k+1=5$ equidistant steps for $\delta=1$ (solid) and $\delta=1.5$ (dashed). Valuations scale with δ while segment sizes remain constant.

so that:

$$\varphi(\delta)=\left\{\frac{k}{k+1}\delta,\frac{k-1}{k+1}\delta,\dots,\frac{1}{k+1}\delta;\frac{1}{k+1},\frac{2}{k+1},\dots,\frac{k}{k+1}\right\}. \tag{15}$$

As illustrated in Figure 4, this structure represents a demand function with k equidistant steps. Consecutive valuations v_{i-1} and v_i differ by $\delta/(k+1)$, scaling with δ. Consecutive segment sizes n_i and n_{i+1} differ by $1/(k+1)$, independent of δ.

To derive $\hat{\Pi}^M(\delta)$ and its comparative statics, we first present the following lemma.

Lemma 3 *Suppose demand is characterized by (15). Since valuations are uniformly spaced, any retail price $p=v_i$ is implementable ($\mathcal{I}=I$). The optimal wholesale price that induces $p=v_i$ is*

$$w_i=\frac{\delta(k+2-2i)}{k+1}.$$

The optimal $\hat{\imath}$ that maximizes M's profit is:

$$\hat{\imath}\in\arg\max_{i\in I} w_i n_i=\arg\max_{i\in I}\frac{\delta(k+2-2i)i}{(k+1)^2}=\frac{k+2}{4}, \tag{16}$$

where the last step follows from the first-order condition, with equality when $k+2$ is divisible by 4. Moreover,

$$\mathcal{J}=\{j\in I\mid \overline{w}_{\hat{\imath}}=w_{\hat{\imath}j}\}=\left\{j\in I|\frac{\delta(k+2-2\hat{\imath})}{k+1}=\frac{\delta(k+1-\hat{\imath}-j)}{k+1}\right\}=\{\hat{\imath}-1\}. \tag{17}$$

At the optimum, the set of binding incentive constraints, $\mathcal{J}$, is a singleton—only the constraint corresponding to the immediately neighboring valuation $v_{\hat{\imath}-1}$ binds.

Proposition 1 *Suppose demand is characterized by (15). Then M's optimal profit is:*

$$\hat{\Pi}^M=\frac{\delta}{8}\left(\frac{k+2}{k+1}\right)^2 \quad \textit{and} \quad \frac{\partial\hat{\Pi}^M}{\partial\delta}=\frac{1}{8}\left(\frac{k+2}{k+1}\right)^2>0.$$

The positive effect of δ has a straightforward intuition. From (17), only the constraint for $j = \hat{\imath} - 1$ binds. Were only $v_{\hat{\imath}-1}$ to increase (as in Section 1), $\hat{\Pi}^M$ would decrease. Here, however, all other valuations also increase along with $v_{\hat{\imath}-1}$. Theorem 1 shows that of these other valuations, $v_{\hat{\imath}}$ raises $\hat{\Pi}^M$, while all others have no effect. Two forces thus compete: a positive effect from increasing the chosen valuation $v_{\hat{\imath}}$ and a negative effect from tightening the binding constraint at $v_{\hat{\imath}-1}$. The positive effect dominates, yielding a net increase in $\hat{\Pi}^M$.

Smooth Demand Functions

Our analysis thus far considers discrete, non-differentiable demand structures. Such step functions are especially appropriate for discrete goods. They are less appropriate when overall demand is relatively large compared to individual units. Indeed, smooth demand functions can be justified as limit cases when unit sizes become arbitrarily small. In this limit, the demand function becomes smooth.

We show this limit perspective also applies to our analysis—it fully carries over to differentiable demand functions when the demand grid becomes arbitrarily fine. We demonstrate this explicitly for the demand structure $\varphi(\delta)$ in (15). As $k \to \infty$, the demand function associated with $\varphi(\delta)$ converges to a linear demand function with intercept 1 and slope $-1/\delta$:

$$\lim_{k\to\infty} D(p|\varphi(\delta)) = 1 - p/\delta.$$

We verify convergence in comparative statics. Computing comparative statics for the discrete demand function $D(p|\varphi(\delta))$ and then taking the limit $k \to \infty$ yields the same result as computing comparative statics directly for the linear demand function $D(p) = 1 - p/\delta$.

From Proposition 1:

$$\lim_{k\to\infty} \frac{d\hat{\Pi}^M(\varphi(\delta))}{d\delta} = \lim_{k\to\infty} \frac{1}{8}\left(\frac{k+2}{k+1}\right)^2 = \frac{1}{8}.$$

We now derive comparative statics for the double marginalization problem with linear demand $D(p) = 1 - p/\delta$ directly, using the backward induction characterization in (2) and (3). R's best response solves:

$$\max_p (p - w)(1 - p/\delta). \tag{18}$$

The first-order condition yields $\hat{p}(w) = (w + \delta)/2$. M's optimal wholesale price solves:

$$\max_w w\left[1 - \frac{w+\delta}{2\delta}\right]. \tag{19}$$

The first-order condition yields $\hat{w} = \delta/2$. Thus M's equilibrium profit is:

$$\hat{\Pi}^M = \frac{\delta}{8}.$$

Confirming the convergence result, the derivative with respect to δ is:

$$\frac{\partial \hat{\Pi}^M}{\partial \delta} = \frac{1}{8} > 0.$$

The convergence between the discrete and the smooth analysis demonstrates robustness but also reveals a fundamental asymmetry in explanatory power. Both approaches establish that $\partial \hat{\Pi}^M / \partial \delta > 0$, but they differ in what they explain. The smooth analysis yields the result by a clean and analytically convenient calculation. Yet it leaves a critical economic question unanswered—what is the economic mechanism by which increasing δ benefits the manufacturer? Only our discrete analysis reveals the answer. It explicitly shows that the overall effect of increasing δ on M's profit is the outcome of a trade-off between two opposing forces—that is, direct profit gains from increases in $v_{\hat{\imath}}$ and indirect profit losses in the form of rent concessions from tightening incentive constraints at $v_{\hat{\imath}-1}$. These two competing forces in the decomposition are ironed out in the smooth limit, where all effects are subsumed within the continuous optimization. For understanding incentive problems in distribution channels, the discrete model is not merely a tractable approximation. It is the framework that makes the economic forces visible.

This asymmetry in explanatory power reflects a deeper methodological insight. Conventional demand analysis typically focuses on a parameterized demand function (e.g., a CES-demand function parameterized by its elasticity, or a linear demand by its slope) and subsequently studies comparative statics in that parameter. While such analysis appears to focus on a single parameter, that parameter typically affects the entire demand curve. This conventional approach obscures which local changes are the key economic factors that drive the results. Our approach reveals that for investment incentives under double marginalization, only specific points on the demand curve matter—demand at the equilibrium price and demand at prices where incentive constraints bind. Changes at these points determine whether investments raise or lower manufacturer profits; changes elsewhere are irrelevant. Smooth parametric analysis obscures this structure by embedding these critical points within continuous optimization. The mechanism design framework makes explicit which aspects of demand govern investment incentives, transforming what appears as a single comparative static into a decomposition of competing forces at distinct prices.

4 Conclusion

This paper examines how distribution channel structures shape manufacturers' incentives to invest in demand. When manufacturers sell through independent retailers who control final pricing, a fundamental tension emerges—investments that enhance demand can have adverse effects by intensifying incentive problems, forcing the manufacturer to concede greater rents and ultimately reducing its profits.

We fully characterize this tension using a mechanism design framework. By recasting the classic double marginalization problem as one of incentive compatibility, we precisely identify which demand parameters affect manufacturer profits and in what ways. Our main result (Theorem 1) shows that manufacturers benefit from increasing demand in segments where they set the final price, but instead benefit from reducing demand in segments where binding incentive constraints compel them to leave rents to retailers. This finding extends to general demand structures and offers a new lens for understanding quality degradation and market segmentation strategies.

Methodologically, our discrete approach reveals that investment incentives depend only on demand at specific prices—the equilibrium price and prices where incentive constraints bind—not on the entire demand structure. Standard parametric demand analysis changes one parameter that affects the entire demand curve, obscuring which aspects of demand actually govern investment decisions. The mechanism design framework makes these sufficient statistics explicit, transforming what appears as a single comparative static into a decomposition of competing forces at distinct prices.

Even our two-valuation benchmark yields predictions consistent with observed distribution patterns. When manufacturers can choose between direct and retail distribution, they strategically adjust product quality only when using retail channels. For low and high valuations, manufacturers use retail distribution and adjust product quality downward and upward respectively. For intermediate valuations, by contrast, they choose direct distribution and maintain product quality. These patterns align with industry observations where manufacturers supply different quality tiers through different channels (Lawton, 2007; Kissell, 2022). Our framework also connects to the literatures on damaged goods and demarketing, suggesting that demand restriction can help mitigate incentive problems associated with double marginalization beyond its role in price discrimination.

Several extensions merit further investigation. First, incorporating asymmetric information about demand or costs would link our results to recent work on information rents in vertical relationships. This extension would also clarify that our results do not critically depend on linear wholesale pricing. As Loertscher and Marx (2022) and Choné et al. (2023) demonstrate, asymmetric information can make simple contracts optimal even when complex mechanisms are available, providing a microfoundation for the pricing structure we analyze. Second, extending to multiple competing retailers would illuminate how horizontal competition interacts with vertical frictions. Finally, empirical work testing our predictions about the relationship between distribution channel choice and quality differentiation would be valuable. These extensions would deepen our understanding of contract design in decentralized distribution systems.

Appendix

This appendix collects the proofs of the lemmas and propositions of the body text.

Proof of Lemma 1: For (w, p) to be feasible, p must be a best response to w. Note that any $p \notin \{v_i | i \in I\}$ is suboptimal for R for any w. Thus, R's best response to any wholesale price w must be a retail price $p = v_i$ for some $i \in I$. Hence, writing

$$\Pi_i^R(w) \equiv (v_i - w)n_i$$

for R's profit from charging $p = v_i$ at wholesale price w, it follows that p is incentive compatible at w if and only if there is an $i \in I$ such that $p = v_i$ and it holds,

$$\Pi_i^R(w) \geq \Pi_j^R(w) \text{ for all } j \in I. \tag{20}$$

Now consider two distinct valuations v_i and v_j. Based on (20), we identify conditions on w such that R prefers $p = v_i$ over any other $p = v_j$. Suppose $j < i$ so that we have $n_i > n_j$. In this case, R prefers $p = v_i$ over $p = v_j$ if and only if

$$\Pi_i^R(w) \geq \Pi_j^R(w) \iff w(n_i - n_j) \leq v_i n_i - v_j n_j \iff w \leq w_{ij}. \tag{21}$$

As (21) has to hold for all $j < i$, it is equivalent to

$$w \leq \overline{w}_i \tag{22}$$

Suppose $j > i$ so that we have $n_i < n_j$. In this case, R prefers $p = v_i$ over $p = v_j$ if and only if

$$\Pi_i^R(w) \geq \Pi_j^R(w) \iff w(n_i - n_j) \leq v_i n_i - v_j n_j \iff w \geq w_{ij}. \tag{23}$$

As (23) has to hold for all $j > i$, it is equivalent to

$$w \geq \underline{w}_i \tag{24}$$

Taken together, the two incentive constraints (22) and (24) are equivalent to (20), and also equivalent to (8).

To see individual rationality, note

$$\Pi_i^R(w) \geq 0 \iff (v_i - w)n_i \geq 0 \iff w \leq v_i.$$

Moreover,

$$w_{ij} \equiv \frac{v_i n_i - v_j n_j}{n_i - n_j} < \frac{v_i n_i - v_i n_j}{n_i - n_j} = v_i. \tag{25}$$

For $i > 1$, since $\overline{w}_i = \min\{w_{ij} \mid j < i\}$ and $w_{ij} < v_i$ for all $j \neq i$ by (25), we have $\overline{w}_i < v_i$. For $i = 1$, $\overline{w}_1 = v_1$ by definition. Thus $w \leq \overline{w}_i \leq v_i$, so the incentive compatibility constraint (8) implies individual rationality. Therefore, (w, p) is feasible if and only if $p = v_i$ for some $i \in I$ and $w \in [\underline{w}_i, \overline{w}_i]$. ■

Proof of Lemma 2: The first statement follows from

$$\hat{w}_i = \arg \max_{w \in [\underline{w}_i, \overline{w}_i]} \Pi^M(w, q(v_i)) = \arg \max_{w \in [\underline{w}_i, \overline{w}_i]} w n_i = \overline{w}_i.$$

For the second statement, note that by the first statement, M's maximum profit when inducing retail price $p = v_i$ is $\Pi_i^M = \overline{w}_i n_i$. Therefore, M's optimal choice among all implementable prices is:

$$\hat{\imath} = \arg \max_{i \in \mathcal{I}} \Pi_i^M = \arg \max_{i \in \mathcal{I}} \overline{w}_i n_i.$$

The third statement follows directly: at the optimal choice $\hat{\imath}$ with wholesale price $\hat{w}_{\hat{\imath}} = \overline{w}_{\hat{\imath}}$ inducing retail price $p = v_{\hat{\imath}}$, we have:

$$\hat{\Pi}^M = \hat{w}_{\hat{\imath}} n_{\hat{\imath}} = \overline{w}_{\hat{\imath}} n_{\hat{\imath}} \quad \text{and} \quad \hat{\Pi}^R = (v_{\hat{\imath}} - \hat{w}_{\hat{\imath}}) n_{\hat{\imath}} = (v_{\hat{\imath}} - \overline{w}_{\hat{\imath}}) n_{\hat{\imath}}.$$

■

Proof of Theorem 1: Since $\hat{\Pi}^M \equiv \overline{w}_{\hat{\imath}} n_{\hat{\imath}}$ by Lemma 2, we analyze each case.

Case 1: $\hat{\imath} \in I$: For $\hat{\imath} = 1$, we have $\overline{w}_1 = v_1$ and thus $\hat{\Pi}^M = v_1 n_1$. Therefore:

$$\frac{\partial \hat{\Pi}^M}{\partial v_1} = n_1 > 0 \quad \text{and} \quad \frac{\partial \hat{\Pi}^M}{\partial n_1} = v_1 > 0.$$

For $\hat{\imath} > 1$, we have $\overline{w}_{\hat{\imath}} = \min\{w_{\hat{\imath}j} \mid j < \hat{\imath}\}$. Since $\hat{\imath} > j$ implies $n_{\hat{\imath}} > n_j$, it follows from the definition of $w_{\hat{\imath}j}$ in (6) that:

$$\frac{\partial \overline{w}_{\hat{\imath}}}{\partial v_{\hat{\imath}}} = \frac{n_{\hat{\imath}}}{n_{\hat{\imath}} - n_j} > 0 \quad \text{for any } j \in \mathcal{J}.$$

Therefore:

$$\frac{\partial \hat{\Pi}^M}{\partial v_{\hat{\imath}}} = n_{\hat{\imath}} \frac{\partial \overline{w}_{\hat{\imath}}}{\partial v_{\hat{\imath}}} = \frac{n_{\hat{\imath}}^2}{n_{\hat{\imath}} - n_j} > 0.$$

For the derivative with respect to $n_{\hat{\imath}}$, using the product rule:

$$\frac{\partial \hat{\Pi}^M}{\partial n_{\hat{\imath}}} = \overline{w}_{\hat{\imath}} + n_{\hat{\imath}} \frac{\partial \overline{w}_{\hat{\imath}}}{\partial n_{\hat{\imath}}}.$$

From (6), for $j \in \mathcal{J}$:

$$\frac{\partial w_{\hat{\imath}j}}{\partial n_{\hat{\imath}}} = \frac{v_{\hat{\imath}}(n_{\hat{\imath}} - n_j) - (v_{\hat{\imath}} n_{\hat{\imath}} - v_j n_j)}{(n_{\hat{\imath}} - n_j)^2} = \frac{(v_j - v_{\hat{\imath}}) n_j}{(n_{\hat{\imath}} - n_j)^2} > 0,$$

where the inequality follows from $j < \hat{\imath}$ implying $v_j > v_{\hat{\imath}}$. Substituting:

$$\frac{\partial \hat{\Pi}^M}{\partial n_{\hat{\imath}}} = \frac{v_{\hat{\imath}} n_{\hat{\imath}} - v_j n_j}{n_{\hat{\imath}} - n_j} + n_{\hat{\imath}} \frac{(v_j - v_{\hat{\imath}}) n_j}{(n_{\hat{\imath}} - n_j)^2} > 0,$$

which can be verified by combining terms over a common denominator.

Case 2: $j \notin \mathcal{J}$**:** For $j \notin \mathcal{J}$, the incentive constraint corresponding to j is non-binding at the optimum. Thus changes in v_j or n_j do not affect $\overline{w}_{\hat{\imath}}$ at the margin, and:

$$\frac{\partial \hat{\Pi}^M}{\partial v_j} = n_{\hat{\imath}} \frac{\partial \overline{w}_{\hat{\imath}}}{\partial v_j} = 0 \quad \text{and} \quad \frac{\partial \hat{\Pi}^M}{\partial n_j} = n_{\hat{\imath}} \frac{\partial \overline{w}_{\hat{\imath}}}{\partial n_j} = 0.$$

Case 3: $j \in \mathcal{J}$ **with** $|\mathcal{J}| = 1$**:** For $j \in \mathcal{J}$, we have $\overline{w}_{\hat{\imath}} = w_{\hat{\imath}j}$. Since $j < \hat{\imath}$ implies $n_{\hat{\imath}} > n_j$, from (6):

$$\frac{\partial \overline{w}_{\hat{\imath}}}{\partial v_j} = \frac{\partial w_{\hat{\imath}j}}{\partial v_j} = \frac{-n_j}{n_{\hat{\imath}} - n_j} < 0.$$

Therefore:

$$\frac{\partial \hat{\Pi}^M}{\partial v_j} = n_{\hat{\imath}} \frac{\partial \overline{w}_{\hat{\imath}}}{\partial v_j} = \frac{-n_{\hat{\imath}} n_j}{n_{\hat{\imath}} - n_j} < 0.$$

Similarly:

$$\frac{\partial \overline{w}_{\hat{\imath}}}{\partial n_j} = \frac{\partial w_{\hat{\imath}j}}{\partial n_j} = \frac{-(v_{\hat{\imath}} n_{\hat{\imath}} - v_j n_j) - (-v_j)(n_{\hat{\imath}} - n_j)}{(n_{\hat{\imath}} - n_j)^2} = \frac{-(v_j - v_{\hat{\imath}}) n_{\hat{\imath}}}{(n_{\hat{\imath}} - n_j)^2} < 0,$$

where the inequality follows from $v_j > v_{\hat{\imath}}$. Therefore:

$$\frac{\partial \hat{\Pi}^M}{\partial n_j} = n_{\hat{\imath}} \frac{\partial \overline{w}_{\hat{\imath}}}{\partial n_j} < 0.$$

Case 4: $j \in \mathcal{J}$ **with** $|\mathcal{J}| > 1$**:** When $|\mathcal{J}| > 1$, multiple constraints bind. As v_j or n_j increases (direction ∂^+), the constraint corresponding to j becomes the unique binding constraint, so by the argument in Case 3, the derivatives are negative.

As v_j or n_j decreases (direction ∂^-), the constraint corresponding to j becomes slack, but other constraints in $\mathcal{J}$ remain binding. Thus $\overline{w}_{\hat{\imath}}$ is determined by these other constraints and does not change at the margin, yielding zero derivatives. ■

Proof of Lemma 3: From the specification in (15), we have $v_i(\delta) = \frac{k+1-i}{k+1}\delta$ and $n_i(\delta) = \frac{i}{k+1}$.

We first compute w_{ij} from (6):

$$w_{ij} = \frac{v_i n_i - v_j n_j}{n_i - n_j} = \frac{\frac{k+1-i}{k+1}\delta \cdot \frac{i}{k+1} - \frac{k+1-j}{k+1}\delta \cdot \frac{j}{k+1}}{\frac{i}{k+1} - \frac{j}{k+1}} = \frac{\delta(k+1-i-j)}{k+1}.$$

For $j < i$, we have $w_{ij} = \frac{\delta(k+1-i-j)}{k+1}$, which is strictly decreasing in j. Thus:

$$\overline{w}_i = \min\{w_{ij} \mid j < i\} = w_{i,i-1} = \frac{\delta(k+1-i-(i-1))}{k+1} = \frac{\delta(k+2-2i)}{k+1}.$$

For $j > i$, we have $w_{ij} = \frac{\delta(k+1-i-j)}{k+1}$, which is strictly decreasing in j. Thus:

$$\underline{w}_i = \max\{w_{ij} \mid j > i\} = w_{i,i+1} = \frac{\delta(k+1-i-(i+1))}{k+1} = \frac{\delta(k-2i)}{k+1}.$$

For implementability, we require $\overline{w}_i \geq \underline{w}_i$:

$$\frac{\delta(k+2-2i)}{k+1} \geq \frac{\delta(k-2i)}{k+1} \iff k-2i+2 \geq k-2i,$$

which holds for all $i \in I$. Thus $\mathcal{I} = I$.

By Lemma 2, the optimal wholesale price that induces $p = v_i$ is $w_i = \overline{w}_i = \frac{\delta(k+2-2i)}{k+1}$.

■

Proof of Proposition 1: By Lemma 3, M's profit when inducing $p = v_i$ is:

$$\Pi_i^M = w_i n_i = \frac{\delta(k+2-2i)}{k+1} \cdot \frac{i}{k+1} = \frac{\delta i(k+2-2i)}{(k+1)^2}.$$

To find the optimal i, we maximize Π_i^M with respect to i. Taking the first-order condition:

$$\frac{\partial}{\partial i}[i(k+2-2i)] = (k+2-2i) + i(-2) = k+2-4i = 0.$$

This yields $\hat{\imath} = \frac{k+2}{4}$ (assuming $k+2$ is divisible by 4 for an integer solution). At this optimum:

$$\hat{\Pi}^M = \frac{\delta\hat{\imath}(k+2-2\hat{\imath})}{(k+1)^2} = \frac{\delta \cdot \frac{k+2}{4} \cdot \left(k+2-2 \cdot \frac{k+2}{4}\right)}{(k+1)^2} = \frac{\delta}{8}\left(\frac{k+2}{k+1}\right)^2.$$

Taking the derivative with respect to δ:

$$\frac{\partial\hat{\Pi}^M}{\partial\delta} = \frac{1}{8}\left(\frac{k+2}{k+1}\right)^2 > 0.$$

■

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