Product Fit Uncertainty and Information Provision in a Distribution Channel

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Abstract

Most consumers considering buying experience goods have some uncertainty about the fit between their tastes and features of products being offered. Information technology has given consumers the ability to conduct research online about their potential fit with products before buying, and modern sellers the ability to disseminate product information to consumers almost costlessly through the Internet. These developments have made provision of product fit information an important strategic decision for sellers. This paper investigates a seller’s incentive to provide such product fit information to consumers when it sells through intermediaries such as retailers. We also examine retailers’ incentives for providing product fit information to consumers on their own, and how they contrast with the seller’s.

(Keywords: Product Fit; Uncertainty; Information Provision; Distribution Channel; Information Technology)
1 Introduction

Most consumers considering buying experience goods (Nelson 1970) have some uncertainty about the fit between their tastes and features of products being offered (e.g., Sun 2011, Hong and Pavlou 2014, Kim and Krishnan 2015). Information technology has given consumers the ability to conduct research online about their potential fit with products before buying,\(^1\) and modern sellers the ability to disseminate product information to consumers almost costlessly through the Internet. These developments have made provision of product fit information an important strategic decision for sellers, and sellers are disclosing product information in cost-effective ways. Many magazine publishers offer electronic sample pages for consumers to “Look Inside,” department stores such as Macy’s and Nordstrom often offer samples of skin care products for consumers to try before they commit to a purchase, and fashion brands such as Warby Parker allow their consumers to virtually try on eye-glasses online. In many cases, the disclosed product information greatly reduces a consumer’s uncertainty regarding his potential fit with the experience good.

Intuitively, disclosure of product fit or product match information helps firms attract well-matched consumers and alienate ill-matched ones.\(^2\) Nondisclosure of product match information, on the other hand, leads to more homogeneity in willingness-to-pay among consumers and hence a high elasticity of demand. Therefore, at the core of the product fit disclosure decision lies the seller’s tradeoff between a product’s margin and its demand (e.g., Anderson and Renault 2006, 2009). Disclosure is aligned with a margin-driving strategy as the product is targeted at well-matched consumers at a premium price, whereas nondisclosure is aligned with a demand-driving strategy as the product is targeted to the mass market at an “average” price. While prior research captures these effects for a firm selling directly to consumers, and demonstrates that the optimal disclosure strategy is a threshold strategy such that the seller withholds product match information if product quality is known to be

\(^1\)Digital content from the Internet is currently the most powerful influence in buying decision as 81% of consumers conduct online research before buying. See HTTP://NEWSROOM.CISCO.COM/RELEASE/1128065 and HTTP://TINYURL.COM/OZQFGAS, accessed in May 2016.

\(^2\)We use the terms “product match” and “product fit” interchangeably.
above a certain threshold (Sun 2011), no research has been done on the optimal disclosure of product match information in the context of a distribution channel. Given that many sellers making product match disclosure decisions sell through downstream retailers, it is important to extend existing models of product match disclosure to incorporate a distribution channel and examine strategic interactions between the nature of retail market competition and a seller’s optimal product match disclosure strategy. Intuitively, since competition among downstream retailers would affect both the total demand and the margin that the seller is able to retain, we would expect retail competition to influence whether she is more likely to use the margin-driving disclosure strategy or the demand-driving nondisclosure strategy when selling through retailers compared to selling directly.\(^3\) Furthermore, a model with a seller selling through downstream retailers would allow us to address additional interesting and relevant questions, such as the incentives of retailers to take it upon themselves to disclose to consumers product match information, if feasible,\(^4\) and whether and when the seller’s and the retailers’ incentives for such a disclosure coincide or diverge.

The goal of this paper is to address the above mentioned questions using a simple model in which a monopolist seller sells either directly or through a distribution channel consisting of two retail outlets located at the end points of the traditional Hotelling line. To capture various degrees of retail competition, we consider the following cases: (i) both retail stores are owned by the same monopolistic retailer, representing least retail competition; (ii) retail stores are owned by independent competing retailers, with different degrees of competition between the retailers captured by varying levels of consumer travel cost between the two retailers, with a higher travel cost implying more differentiated retailers and a lesser degree of retail competition.

Our first main result centers around how the change in the seller’s optimal disclosure

\(^3\)We refer to the seller as “she” and the consumer as “he.”

\(^4\)Clothing retailer Guilt, for example, has its own in-house photo studio set up in Brooklyn offices where it shoots models wearing items it carries (Yarrow 2010). Some retailers offer sales assistance such as “live chat” to answer consumers’ questions about their products. Casper.com, a retailer of mattresses, identifies reviewers with locations and sleeping habits so that a potential consumer could evaluate his fit with a mattress by seeking out like-minded reviewers (casper.com/reviews, accessed in April 2017).
policy from selling directly to selling through a distribution channel is affected by the nature of retail competition. When the seller sells through a monopolistic retailer or two highly differentiated retailers, she is more likely to use nondisclosure strategy compared to selling directly. Intuitively, when retailers are more differentiated, they have market power and charge a high markup, keeping the demand low. The high retail markup reduces the seller’s return from the margin-driving disclosure strategy, making the demand-driving nondisclosure strategy more attractive. Thus, the seller is more likely to use the nondisclosure strategy when she sells through differentiated retailers compared to when she sells directly. On the other hand, when the seller sells through less differentiated and more competitive retailers, she is more likely to disclose product-fit information compared to when she sells directly. Intuitively, when the retailers are competitive, their price competition leads to low retail markups, keeping the demand high. The high demand reduces the seller’s return from the use of demand-driving nondisclosure strategy, making the margin-driving disclosure strategy more attractive. Overall, there is no one direction in which the seller’s product-fit information disclosure strategy changes as she sells through a distribution channel rather than directly. It could go in either direction — increased use of disclosure strategy or increased use of nondisclosure strategy — depending on how competitive the retailers are.

Our second main result pertains to the situation in which the retailers themselves have the capability to provide product-fit information. We find that they choose disclosure when the seller’s product quality is either very low or very high, and choose nondisclosure when the seller’s quality reputation takes an intermediate value. Intuitively, when quality is very low, disclosure helps retailers get reasonable demand from well-matched consumers at a reasonable margin. When quality is very high, disclosure helps the retailers get a larger share of the total channel profit as it makes demand less elastic and leaves more room for retail markup. However, when quality is mediocre, the dominant effect of disclosure is to alienate ill-matched consumers, which makes it undesirable for the retailers.

Overall, the retailers and seller all find a disclosure strategy optimal for low values of product quality, neither finds it optimal for intermediate values of product quality, and only
the retailers find it optimal for high values of product quality.

**Relationship to Literature.** A number of empirical studies have shown how product uncertainty adversely affects consumer purchase and how sellers can use Internet-enabled information disclosure strategies to counter this problem. For example, in an empirical study of hundreds of product categories, Kim and Krishnan (2015) show how product-fit uncertainty adversely affects consumer purchase of higher-priced products, and how sellers can use technology such as digitized videos to reduce such product fit uncertainty for consumers. Hong and Pavlou (2014) use data from eBay and online Tobacco marketplace to show that product fit uncertainty has more adverse effect on product return than product quality uncertainty. They also show Internet-enabled online product forms can reduce the product fit uncertainty. Other empirical studies focus on product-quality uncertainty. For example, Ghose (2009) examines data on used goods trading market across many product categories to show that seller uncertainty and quality-related product uncertainty lead to adverse selection, which does not completely disappear even with mechanisms such as seller reputation feedback and product quality disclosure. Dimoka et al (2012) use online auction data on used car and show causes of consumer uncertainty about quality of products and that product quality uncertainty has more adverse effect on the price than uncertainty about seller.

Among economics-based theoretical research, while a large number of papers have examined a seller’s incentive to disclose its product quality, a relatively small number of papers have focused on disclosure of product match or product fit information. Given that our paper falls in the latter set, we explain our connection with that literature first.

Chen and Xie (2008) explore the relationship between consumer reviews and seller disclosure, both of which deliver information on consumer’s match with the product, and find that the two forms of disclosure can be either substitutes or complements depending on cost of the product and sophistication of product users. Sun (2011) models multiple product attributes and shows that disclosure occurs when quality is low and that the unravelling result may break down when disclosure reveals information on both quality and match. Mayzlin and
Shin (2011) and Branco et al. (2016) explore the interaction between a seller’s information provision and consumers’ information search and highlight equilibria of partial disclosure. Recent studies also explore the effect of competition on the disclosure of product match information (e.g., Shaffer and Zettelmeyer 2004, Anderson and Renault 2009, Gu and Xie 2013). Jiang and Guo (2015) model the optimal consumer review system and its effect on product prices when consumers are uncertain of both product quality and product fit, and the first-period reviews left by consumers reduce the uncertainty of second-period buyers.

In contrast to these papers, our paper examines disclosure of product match information in the context of a distribution channel. The only other study that relates fit revelation to the structure of a distribution channel is Gu and Liu (2013), who characterize the optimal shelf layout and find that whether competing products should be displayed together depends on the difference in the products’ ex-ante fit probabilities as well as the intensity of retail competition. However, they model search goods so that consumers always learn the match before making a purchase, while we focus on experience goods for which consumers may not know their match until after the purchase.

Less related to our paper is the vast literature on disclosure of product quality. In their seminal papers, Grossman (1981) and Milgrom (1981) establish the unravelling result: all levels of quality will be revealed in equilibrium, as the highest quality type in any pooling equilibrium would want to separate from the other types in the pool. Subsequent studies often characterize a quality threshold above which the seller would choose to disclose the quality of the product, and document how this threshold changes with factors such as disclosure costs (Jovanovic 1982) and consumer’s uncertainty about their preference for quality and asymmetry in firms’ quality levels (Kuksov and Lin 2010). In contrast to this body of work that focuses on disclosure of product quality or real-time demand shocks (e.g., Gal-Or et al. 2008), our paper examines incentives to disclose the horizontal match between the product and individual consumers with heterogeneous tastes. Our paper is therefore more applicable to product categories in which a major source of the uncertainty in a consumer’s valuation of a product comes from the fit between the product and its tastes.
Finally, another stream of related literature is the one on product returns (e.g., Ofek et al. 2011, Hong and Pavlou 2014). Conceptually, pre-purchase disclosure and post-purchase product returns could both serve the purpose of disclosing product match information. The two strategies, however, differ significantly in practice. First, pre-purchase disclosure typically incurs lower marginal cost to firms than product returns. While pre-purchase disclosure is often implemented through digital technologies with high fixed cost and low marginal cost, firms typically have to incur substantial shipping and restocking costs for each returned item. Second, pre-purchase disclosure also costs less to consumers while returns are associated with the hassle of packing and shipping and sometimes hefty shipping charges. Overall, our paper focuses on the question of how the structure of distribution channel would affect pre-purchase product-fit information disclosure.

The remainder of the paper is organized as follows. In the next section, we set up our model. Section 3 examines seller’s product-fit information disclosure strategy in the context of a distribution channel, and Section 4 examines the disclosure incentives for the retailers. Section 5 concludes with a discussion of some limitations of the current model and ideas for possible extensions.

2 The Model

There is a seller that sells a product to consumers either directly or through a distribution channel, using two retail outlets located at the end points of a Hotelling line of unit length. Consumers are heterogeneous on two dimensions — their tastes for the product and their preference for (or distance from) the two retail stores. Each consumer’s preference for the product is independent of his preference for (or distance from) the stores.\(^5\)

Formally, suppose a unit mass of consumers are distributed uniformly in the unit square. The \(x\)-axis represents consumers’ ideal store types, and the \(y\)-axis represents their ideal

\(^5\)In reality, the store type could also be affected by the products that it carries. Our analysis essentially requires that consumers cannot infer the product’s type from the store that carries it. That is, after seeing the store that sells the product, the consumer still faces significant uncertainty regarding his potential fit with the product.
product types. The two stores in our model are located at \( x_s = 0 \) and \( x_s = 1 \), and these locations are common knowledge. They can be jointly owned by the seller or a monopolistic retailer, or separately owned by two different retailers. The product’s type, captured by its location, is a random variable that takes the value of \( y_p = 0 \) or \( y_p = 1 \) with equal probability. Since consumers are uniformly distributed, the two product types are symmetric. A consumer located at \((x, y)\) buys at most one unit of the product and gains utility

\[
U(x, y) = v - p - t_x \cdot x - t_y \cdot y
\]

from the purchase, where \( v > 0 \) is the seller’s product quality. The consumer is willing to pay \( v \) if his fits with the product and the store are both perfect. Other parameters in the utility function are \( p \), the price of the product; \( x \), the distance between the consumer’s ideal type of store and the actual location of the store on the \( x \)-axis; \( y \), the distance between the consumer’s ideal type of product and the actual location of the product on the \( y \)-axis; and \( t_x \) (resp. \( t_y \)), the weight that is placed by the consumer on the store (product) mismatch.

To ease interpretation, we rewrite the consumers’ utility function so that results can be discussed in terms of the relative importance of product and store mismatch:

\[
u(x, y) \equiv \frac{U(x, y)}{t_y} = \frac{v - p - t_x \cdot x - t_y \cdot y}{t_y} \equiv v' - p' - t \cdot x - y,
\]

where \( v' = \frac{v}{t_y} \) is the normalized quality vis-à-vis the importance of product mismatch, \( p' = \frac{p}{t_y} \) is the normalized price, and \( t = \frac{t_x}{t_y} \) is the relative importance of store mismatch. Without loss of generality, we normalize the importance of product mismatch \( t_y \) to 1 so that \( v' = v \), \( p' = p \) and \( t = t_x \). When \( t_y \) is different from 1, the consumer’s utility, as well as the channel members’ margins and profit, can all be obtained by multiplying the current equilibrium outcomes by \( t_y \), and results on pre-purchase product-fit disclosure would remain the same.

One way to interpret parameter \( t \) is to think of it as the “travel cost” parameter, an increase in which increases the relative weight that consumers put on their distance from a store. The lower is \( t \), the less consumers care about the difference between retailers, and the
more intense is downstream retail competition. We assume \( t \in (0, 1] \) so that retailers may find it optimal to compete in equilibrium.

While other variables in the consumer’s utility function are common knowledge, the product’s type, and hence the product fit with consumers, is not known to the consumers without the seller or retailer choosing to disclose this information. This assumption reflects our observation that it may be harder for consumers to learn their fit with a particular product (e.g., Adobe Photoshop) than to learn the seller’s general quality reputation, as information on the latter can often be found online. We assume that if the seller or retailers choose disclosure (e.g., offer a free trial for Adobe Photoshop, a virtual trial online for eyeglasses, online sample pages of magazines), the disclosed information is truthful and all consumers observe the product’s type. Otherwise, the consumers keep their prior belief that the product is located at \( y_p = 0 \) or \( y_p = 1 \) with equal probability.\(^6\)

Since we model preference heterogeneity on two dimensions (store and product) in a continuous framework, certain modeling assumptions are necessary to keep the model well defined and tractable. For example, the linear mismatch costs along both dimensions enable us to analyze all possible demand scenarios. With quadratic mismatch costs, optimal disclosure strategy can only be characterized for the extreme cases of local monopolies and complete market coverage.\(^7\) Also, by fixing the stores at the two ends of the Hotelling line, we can sidestep discontinuous demand functions that tend to emerge when firms are close to each other (d’Aspremont et al. 1979; Tirole 1988). Finally, by using the widely observed linear pricing contract between the seller and the retailer, we can examine the seller’s demand and margin tradeoff behind the disclosure decision.\(^8\)

\(^6\)Technically, a nondisclosing seller could use her price to signal the product’s location. However, in an equilibrium where the two types choose nondisclosure and charge different prices, at least one of them can profitably deviate to disclosure. Therefore, the two types always charge the same price under nondisclosure.

We assume that this price is profit maximizing. An off-equilibrium-path belief that supports this assumption is that consumers believe that the product is located at 0 when a different price is charged.

\(^7\)For example, if the utility of consumer \((x, y)\) is \( v - p - x^2 - y^2 \), we can obtain that under disclosure (nondisclosure), the two retailers remain local monopolies in equilibrium if \( v \leq 1 \) (resp. \( \frac{1}{4} < v \leq \frac{3}{4} \)), in which case the seller’s profit is \( \frac{1}{16} \pi v^2 \) (resp. \( \frac{v}{2} (v - \frac{1}{2})^2 \)). She prefers to choose disclosure if \( v < 0.85 \). On the other hand, the retailers will compete head to head and cover the entire market under disclosure (nondisclosure) if \( v \geq \frac{9}{4} \) (resp. \( v \geq \frac{7}{4} \)), in which case the seller’s profit is \( v - \frac{9}{4} \) (resp. \( v - \frac{7}{4} \)). She prefers nondisclosure.

\(^8\)With a two-part tariff, the seller could use the fixed fee to extract the entire channel profit. As a result,
3 Seller’s Product-Fit Information Disclosure Strategy

We derive the seller’s optimal information disclosure strategy under various channel structures in Sections 3.1, 3.2, and 3.3, and compare them to summarize the effect of distribution channel on its disclosure strategy in Section 3.4. Section 4 takes the perspective of retailers, and examines their incentives for product-fit information disclosure.

3.1 Seller Selling Directly to Consumers

When the seller owns both stores and sells directly to consumers, the game proceeds as follows: First, the seller learns the product’s location ($y_p = 0$ or $y_p = 1$) and decides whether to disclose it to consumers. She then sets a price $p$ and consumers each decide whether to buy the product. We solve the game backward by comparing the seller’s profit levels in the disclosure and nondisclosure subgames. As a tie-breaking rule, we assume throughout the paper that a channel member chooses disclosure when it is indifferent between disclosure and nondisclosure.

If Seller Does not Disclose. Suppose the seller does not disclose the product’s location. The utility of the consumer located at $(x, y)$ is $v - p - t \cdot x - \frac{1}{2}$ if he buys from the store located at $x_s = 0$ and $v - p - t \cdot (1 - x) - \frac{1}{2}$ if he buys from the store located at $x_s = 1$. Note that the expected product mismatch cost is $\frac{1}{2}$ for all consumers: $\frac{1}{2} (y - 0) + \frac{1}{2} (1 - y) = \frac{1}{2}$ for $y \in [0, 1]$. Depending on the values of $v$ and $p$, the demand is then as shown in Figure 1 below.

A consumer’s willingness to pay in this case is solely determined by his distance to the closest store. The highest willingness to pay in the entire population is $v - \frac{1}{2}$, obtained by the consumers located at zero distance to one of the two stores. The lowest willingness to pay is $v - \frac{t}{2} - \frac{1}{2}$, obtained by consumers located at equal distance from the two stores. If the price is higher than $v - \frac{1}{2}$, no one buys the product, and if the price is lower than $v - \frac{t}{2} - \frac{1}{2}$, everyone buys the product. When the price is in between these two levels, the consumers she would always stick to her disclosure strategy under selling direct.
Figure 1: Seller Sells Directly to Consumers: Nondisclosure Subgame

Note: The shaded areas indicate demand for the product. Consumers in the left shaded area buy from the store at $x_s = 0$ and consumers in the right shaded area buy from the store at $x_s = 1$.

located close to one of the two stores would buy the product while others located near the middle of the two stores would not buy. The indifferent consumers are located at distance $x^*$ away from the closer store such that $v - t \cdot x^* - p - \frac{1}{2} = 0$. The seller hence maximizes $p \cdot \frac{2}{t}(v - p - \frac{1}{2})$ and charges an optimal price of $\frac{1}{2}(v - \frac{1}{2})$. The corresponding demand is $(v - \frac{1}{2})\frac{1}{t}$. In order for the demand to fall in the middle scenario depicted in Figure 1, quality $v$ can neither be too low nor too high. Summarizing across all possible demand scenarios, we get the seller’s maximum profit as

$$\pi_{ND} = \begin{cases} 
0 & \text{if } 0 < v < \frac{1}{2}, \\
\frac{(2v-1)^2}{8t} & \text{if } \frac{1}{2} \leq v < t + \frac{1}{2}, \\
v - \frac{1}{2} - \frac{1}{2} & \text{if } v \geq t + \frac{1}{2}.
\end{cases}$$

(1)

As expected, the seller’s profit and market coverage increase as the product’s quality $v$ increases and as the consumers’ travel cost $t$ decreases.

If Seller Discloses. Suppose now that the seller discloses the product’s location. Without
loss of generality, let the product location \( y_p \) be 0. The utility of the consumer located at \((x, y)\) is then \( v - p - t \cdot x - y \) if he buys from the store at \( x_s = 0 \), and \( v - p - t \cdot (1 - x) - y \) if he buys from the store at \( x_s = 1 \). Depending on the values of \( v \) and \( p \), the demand is then as shown in Figure 2.

**Figure 2: Seller Sells Directly to Consumers: Disclosure Subgame**

\[
\pi_D = \begin{cases} 
\frac{4v^3}{27t} & \text{if } 0 < v < \frac{3t}{4}, \\
\frac{(4v-t)^2}{64} & \text{if } \frac{3t}{4} \leq v < \frac{8-t}{4}, \\
\frac{(4+2t-4v-Z_1)(t^2+t(Z_1-4v-8)-2(v-1)(Z_1+2-2v))}{108t} & \text{if } v \geq \frac{8-t}{4},
\end{cases}
\]

where \( Z_1 = \sqrt{t^2 + 4(v-1)^2 - 4t(v-4)} \). As in the nondisclosure subgame, market coverage increases as product quality increases. Interestingly, the seller never finds it optimal to sell to everyone under disclosure. This is consistent with our intuition that disclosure is a margin-driving strategy that the seller uses to target the better matched consumers.

Comparing the profit functions under disclosure and nondisclosure, from equations (1)
and (2), we get the optimal information disclosure strategy of the seller as follows:

**Proposition 1:** A seller selling directly to consumers chooses to provide product-fit information iff \( v < v_1(t) \), where \( v_1(t) \) increases in \( t \). Specifically, \( v_1(t) = (i) 2 + \frac{t}{4} - \sqrt{2 - t} \) for \( 0 \leq t < 0.2222 \), and (ii) \( \frac{1}{2} + \frac{t}{4} + \frac{\sqrt{t}}{4} \) for \( 0.2222 \leq t \leq 1 \).

This baseline result and intuition behind it is similar to that shown in Sun (2011). It suggests that the seller has a stronger incentive to disclose the product’s type and hence its match with the consumers when the product quality is low. When quality is low, most consumers are not interested and match disclosure in this case helps the seller secure demand from the well-matched consumers. When quality is high, on the other hand, most consumers are already willing to pay a reasonable price for the product. The dominant effect of match disclosure in this case is to drive away ill-matched consumers and the seller is more likely to choose nondisclosure. Note that the seller is also more likely to choose disclosure as the travel cost increases. Essentially, a consumer’s net willingness to pay decreases as the travel cost increases, and the seller once again uses disclosure to increase her margin and secure demand from the well-matched consumers.

### 3.2 Seller Selling through a Monopolistic Retailer

Suppose now the seller distributes her product through a monopolistic retailer who owns both stores. Similar to the consumers, the retailer has to learn the product’s type through seller disclosure. As before, the seller first decides whether to disclose her product location and then sets a wholesale price \( w \). Next, the retailer sets a final price \( p \) and consumers each decide whether to buy the product.

**If Seller Does not Disclose.** As in the case of selling direct, there are three possible demand scenarios under nondisclosure: no demand, partial market coverage, and full market coverage. The consumers located at zero distance from one of the two stores have the highest willing to pay, \( v - \frac{1}{2} \), and the consumers located at equal distance from the two stores have the lowest willing to pay, \( v - \frac{t}{2} - \frac{1}{2} \). When price is in between these two levels, the indifferent
consumers are located at a distance $x^*$ from the closer store such that $v - p - t \cdot x^* - \frac{1}{2} = 0$. This determines the retailer's demand and his maximization problem as

$$\max_p (p - w) \cdot \frac{2(v - p - \frac{1}{2})}{t},$$

which leads to $p^* = \frac{1}{2}(v + w - \frac{1}{2})$. If the retailer decides to cover the entire market, on the other hand, the optimal price would be $v - \frac{1}{2} - \frac{t}{2}$, and his profit would be $v - \frac{1}{2} - \frac{t}{2} - w$. Comparing the two profit levels, the retailer finds it optimal to cover the entire market if $v - w > t + \frac{1}{2}$.

Given the retailer’s pricing strategy, the seller then maximizes her profit. If she charges a high wholesale price so that the retailer does not cover the entire market, the seller’s profit is then $w \cdot \frac{2}{t} \cdot (v - p^* - \frac{1}{2})$, which leads to $w^* = \frac{1}{2}(v - \frac{1}{2})$ and $p^* = \frac{3}{4}(v - \frac{1}{2})$. The corresponding demand is $\frac{2v-1}{4t}$ and the corresponding profit is $\frac{(2v-1)^2}{16t}$. If she charges a low wholesale price so that the market is covered, her profit is then $v - t - \frac{1}{2}$. She compares these two strategies and chooses the one that leads to a higher profit. Putting all demand scenarios together, we obtain the seller’s maximum profit as

$$\pi_{ND} = \begin{cases} 0 & \text{if } 0 < v < \frac{1}{2}, \\ \frac{(2v-1)^2}{16t} & \text{if } \frac{1}{2} \leq v < 2t + \frac{1}{2}, \\ v - t - \frac{1}{2} & \text{if } v \geq 2t + \frac{1}{2}. \end{cases} \quad (3)$$

As before, the seller’s profit and market coverage increase as the product’s quality increases and as the consumers’ travel cost decreases. Comparing the seller’s profit here with that when she sells directly to consumers, one can confirm that her profit is lower when the retailer is introduced.

**If Seller Discloses.** When the seller chooses disclosure, the retailer faces three possible demand scenarios as shown in Figure 2. Consider the first scenario in which the two stores are local monopolies. Given wholesale price $w$, a retailers’ demand is $\frac{1}{2t}(v - p)^2$, his margin is $p - w$, and the optimal price is $\frac{1}{3}(v + 2w)$. Within this demand scenario, the seller maximizes
her profit and charges \( w_D = \frac{v}{9} \). For the two stores to remain local monopolies, the demand for each retailer must be smaller than \( \frac{1}{4} \), which implies \( v < \frac{9t}{8} \). Solving for the optimal price in each demand scenario, and comparing the seller’s profit across all possible scenarios for each level of product quality, we can obtain the seller’s maximum profit as follows.

\[
\pi_D = \begin{cases} 
\frac{16v^3}{213t} & \text{if } 0 < v < \frac{9t}{8}, \\
\frac{(4v-3t)t}{16} & \text{if } \frac{9t}{8} \leq v < \frac{5t}{4}, \\
\frac{(4v-t)^2}{128} & \text{if } \frac{5t}{4} \leq v < \frac{16-3t}{4}, \\
\frac{(4v+t-8)(4-t)}{16} & \text{if } \frac{16-3t}{4} \leq v < \frac{16+24t-5t^2}{8t}, \\
Z_2 & \text{if } v \geq \frac{16+24t-5t^2}{8t},
\end{cases}
\]

(4)

where the long expression of \( Z_2 \) has been relegated to the Appendix.

Comparing the profit functions under disclosure and nondisclosure, from equations (3) and (4), we get the optimal disclosure policy of the seller as follows:

**Proposition 2:** A seller selling through a monopolistic retailer chooses to provide product-fit information iff \( v < v_2(t) \), where \( v_2(t) \) increases (weakly) in \( t \). Specifically, \( v_2(t) = (i) 4 - \sqrt{6(2-t)} + \frac{t}{4} \) for \( 0 \leq t < 0.0408 \); (ii) \( \frac{1}{4} \left(2 + t + \sqrt{2t}\right) \) for \( 0.0408 \leq t < 0.82 \); (iii) \( \frac{1}{2} \left(1 + t^2 + t\sqrt{2 - (3-t) t}\right) \) for \( 0.82 \leq t < 0.9425 \); and (iv) 1.06 for \( 0.9425 \leq t < 1 \).

As before, increased travel cost lowers the consumer’s net willingness to pay, prompting the seller to use disclosure to secure demand from well-matched consumers.

### 3.3 Seller Selling through Competing Retailers

Suppose now the seller distributes her product through two competing retailers, each owning one of the two stores. Without loss of generality, suppose retailer A owns the store located at \( x_s = 0 \) and retailer B owns the one located at \( x_s = 1 \). The game remains the same as the one with a monopolistic retailer except that the two retailers now choose their prices simultaneously. To keep the analysis tractable, we focus on the symmetric equilibrium in which they choose the same price.
If Seller Does not Disclose. When the two retailers do not compete with each other, the seller’s profit is the same as when she sells through a monopolistic retailer. When the two retailers compete, the market is completely covered. The indifferent consumers are given by
\[ v - p_A - \frac{1}{2} - tx = v - p_B - \frac{1}{2} - t(1 - x) \] such that \( x = \frac{p_B - p_A + t}{2t} \). Retailer A hence maximizes \((p_A - w) \cdot \frac{p_B - p_A + t}{2t}\), which leads to \( p_A^* = \frac{p_B + t + w}{2} \). By symmetry, we know that retailer B follows the same strategy so that \( p_B^* = \frac{p_A + t + w}{2} \). Putting the two best response functions together, we arrive at the equilibrium prices \( p_A^* = p_B^* = t + w \). To ensure that the consumers at the middle get positive utility at these prices, we need \( v - w > \frac{3}{2}t + \frac{1}{2} \). When the two retailers remain local monopolies, on the other hand, the optimal prices are the same as when there is a monopoly retailer: \( p_A^* = p_B^* = \frac{1}{2}(v + w - \frac{1}{2}) \). In order for the consumers at the middle to get negative utility at this price so that the retailers remain local monopolies, we need \( v - w < t + \frac{1}{2} \). When \( t + \frac{1}{2} \leq v - w \leq \frac{3}{2}t + \frac{1}{2} \), the retailers cover the entire market and yet do not compete with each other: \( p_A^* = p_B^* = v - \frac{1}{2} - \frac{t}{2} \). The seller takes the retailers’ pricing strategy into account when setting the wholesale price \( w \) to maximize her profit, and her maximum profit is

\[
\pi_{ND} = \begin{cases} 
0 & \text{if } 0 < v < \frac{1}{2}, \\
\frac{(2v-1)^2}{16t} & \text{if } \frac{1}{2} \leq v < 2t + \frac{1}{2}, \\
v - t - \frac{1}{2} & \text{if } v \geq 2t + \frac{1}{2}.
\end{cases}
\] (5)

If Seller Discloses. When the seller chooses disclosure, the two retailers would need to select their prices in order to maximize their profit over the three possible demand scenarios shown in Figure 2. Following the same steps as before, we solve for the optimal price in each demand scenario. Comparing the seller’s profit across all possible scenarios for each level of product quality, we obtain the seller’s maximum profit as follows:
\[ \pi_D = \begin{cases} 
\frac{16v^3}{243t} & \text{if } 0 < v < \frac{9t}{8}, \\
\frac{(4v-3)t}{16} & \text{if } \frac{9t}{8} \leq v < \frac{19t}{16}, \\
Z_3 & \text{if } \frac{19t}{16} \leq v < \frac{-3t^2 + 10t^2 + 22t + 16}{2t^2 + 4t + 4}, \\
\frac{t^2 + 2tv - 6t + 4v - 4}{2t+4} \cdot (1 - \frac{t}{4}) & \text{if } \frac{-3t^2 + 10t^2 + 22t + 16}{2t^2 + 4t + 4} \leq v < \frac{-t^2 + 19t + 8}{t^2 + 4t + 4}, \\
Z_4 & \text{if } v \geq \frac{-t^2 + 19t + 8}{t^2 + 4t + 4}, 
\end{cases} \]

where the long expressions of \( Z_3 \) and \( Z_4 \) are in the Appendix. Comparing the profit functions under disclosure and nondisclosure, from equations (5) and (6), we get the optimal disclosure policy of the seller as follows:

**Proposition 3:** A seller selling through two competing retailers chooses to provide product-fit information iff \( v < v_3(t) \), where \( v_3(t) \) increases (weakly) in \( t \). Specifically, \( v_3(t) = (i) \, \frac{t}{4} \) for \( 0 \leq t < 0.083 \); (ii) \( \frac{t}{4} \) for \( 0.083 \leq t < 0.605 \); (iii) \( \frac{t}{4} \) for \( 0.605 \leq t < 0.884 \); (iv) \( \frac{t}{4} \) for \( 0.884 \leq t < 0.943 \); and (v) 1.06 for \( 0.943 \leq t < 1 \).

The full expressions of \( v_3^I(t) \), \( v_3^II(t) \), \( v_3^III(t) \) and \( v_3^IV(t) \) are presented in the Appendix. This result allows us to examine how the seller’s optimal disclosure strategy changes with the parameter \( t \).

**Lemma 1:** When a seller sells through two competing retailers, an increase in retailer differentiation, as captured by an increase in travel cost \( t \), makes the seller more likely to provide product-fit information.

Two effects drive this result. First, as before, consumers’ net willingness to pay for the product decreases as travel cost increases. As the average willingness to pay lowers, the seller has more incentive to use disclosure to increase her margin and secure positive demand. Second, as \( t \) increases, retailers face weaker competition from each other and possess stronger market power over the seller. The substantial retail markup limits the effectiveness of nondisclosure in expanding demand. As a result, the seller is more likely to choose disclosure in order to increase the total margin and hence also the wholesale margin.
3.4 Effect of Distribution Channel on Optimal Information Disclosure Strategy

Using Propositions 1, 2, and 3, we can see how the seller’s thresholds for product-fit information disclosure change across different channel structures. Figure 3 represents these thresholds graphically,\(^9\) and the following Proposition summarizes the comparison of the thresholds.

Figure 3: Channel Structure and the Seller’s Disclosure Threshold

\[ v \]

\[ t \]

Note: The seller chooses disclosure iff product quality is below the disclosure threshold. The dashed curve represents the disclosure threshold when the seller sells directly to consumers, the dotted curve represents that when she sells through a monopolistic retailer, and the solid curve represents when she sells through duopolistic retailers.

\(^9\)It is important to note that while the disclosure thresholds appear to be close to each other in the figure, the seller’s gain from following the optimal disclosure strategy is substantial. When quality is below \( \frac{1}{2} \), for example, the seller cannot make any profit under nondisclosure, while she can make positive profit under disclosure. As quality increases, the seller’s profit grain from disclosing product match information decreases and eventually becomes negative.
Proposition 4: Compared to the case where a seller sells directly to consumers,

1. If the seller sells through a monopolistic retailer, then she is less likely to disclose product fit information;

2. If the seller sells through two competing retailers, then she is
   
   (a) less likely to disclose product fit information if the retailers are less differentiated i.e., $t < 0.855$,
   
   (b) more likely to disclose product fit information if the retailers are more differentiated, i.e., $t \in [0.855, 1]$.

The first part of the proposition suggests that exclusive dealing tends to minimize seller disclosure of product match information. The intuition is as follows. Given a fixed level of travel cost, double marginalization is most severe when the seller sells through a monopolistic retailer. Nondisclosure strategy can then help the seller to effectively limit the retail markup, since nondisclosure makes the consumers’ willingness to pay more homogeneous and the demand more elastic. As a result, the seller finds nondisclosure attractive when she sells through a powerful monopolistic retailer. Disclosure of product-fit information in this case would enable the retailer to charge a steep mark up and target the best-matched consumers, which in turn reduces the seller’s share of the total channel profit.

Compared to selling direct, the seller incurs a loss in both her margin and demand when competing retailers are present. When retailers are more differentiated, they have market power which they use to charge a high markup, keeping the demand low. This high retail markup reduces the seller’s return from the use of margin-driving disclosure strategy, and makes the demand-driving nondisclosure strategy more attractive. Thus, overall, the seller is more likely to use the nondisclosure strategy when she sells through more differentiated retailers compared to when she sells directly. On the other hand, when the retailers are very competitive, their price competition leads to low retail markups, keeping the demand high.
This high demand reduces the seller’s return from the use of demand-driving nondisclosure strategy, and makes the margin-driving disclosure strategy more attractive.

4 Retailers’ Product-Fit Information Disclosure Strategy

There are many situations in which the retailer also has information about consumers’ potential fit with the product and the technological means to disclose such information. Casper.com, an online retailer of mattresses, identifies the reviewers with real names, locations, and sleeping habits so that a potential consumer could evaluate his fit with a mattress by seeking out a reviewer who has similar taste to himself. Car dealers offer test drives, learn consumers’ preferences on the spot, and offer individual consultation regarding their match with a particular car.

For situations like these, we are interested in learning how the retailers’ optimal disclosure strategy may differ from that of the seller. We present here the retailer disclosure game with duopolistic retailers, as analysis with a monopolistic retailer yields the same qualitative conclusions. The timeline of the game is as follows. First, the two retailers learn the product’s location and choose whether to disclose it to consumers. The seller then sets the wholesale price. Next, retailers simultaneously set retail prices and consumers each decide whether to purchase one unit of the product.

An important feature of the timeline is that the disclosure decision is made before pricing decisions. The assumption reflects our observation that retailers often need to commit to a particular disclosure technology (e.g., professional shooting of product pictures, virtual try-on, demo versions) before wholesale and retail prices are chosen. To acknowledge the fact that consumers often engage in comparison shopping across retailers, we also assume that disclosure from a single retailer is sufficient for all consumers to learn the product’s location.

We start the analysis with the benchmark case of \( t = 1 \) and later consider a general \( t \).

**Lemma 2:** For \( t = 1 \), the retailers choose disclosure of product fit information for very low or very high values of product quality (\( v < 1.28 \) and \( v > 3.77 \)), and nondisclosure otherwise (\( 1.28 < v < 3.77 \)).

Based on our analysis in Section 3.3, the seller in this case chooses disclosure if and only if quality is low, \( 0 < v < 1.10 \), which contrasts with the retailers’ bell-shaped disclosure strategy in Lemma 2. We explain below the difference in the channel members’ optimal disclosure strategies by looking at the different ranges of quality.

First, when quality is low (\( 0 < v \leq 1.10 \)), all channel members prioritize the need to secure positive demand from well-matched consumers. As a result, they all prefer disclosure. As quality increases (\( 1.10 < v \leq 1.28 \)), the optimal demand under nondisclosure begins to exceed that under disclosure (see Figure 4). The retailers’ margin is higher under disclosure, while the seller’s wholesale prices are close in the two subgames. As a result, the retailers prefer disclosure while the seller prefers nondisclosure.

When quality further increases (\( 1.28 < v < 3.77 \)), the seller and retailers all prefer nondisclosure, as the larger gain in demand starts to outweigh the loss in their margins. Finally, when quality reputation is very strong (\( v \geq 3.77 \)), the market is almost completely covered under both disclosure and nondisclosure. Retailers in this case could obtain a significant margin under disclosure, while the seller has to cut the wholesale price significantly to induce sales to the marginal consumers. Under nondisclosure, on the other hand, the seller can extract most of the consumer surplus, while retailers compete aggressively in price given the elastic demand curve. As a result, the retailers prefer disclosure while the seller prefers nondisclosure.

The following proposition shows that the retailers’ bell-shaped disclosure strategy carries over to a general value of parameter \( t \).

**Proposition 5:** When \( t \in [0.043, 1] \), the retailers choose nondisclosure of product-fit information for an intermediate range of quality, and disclosure otherwise. When \( t \in (0, 0.043) \),
they always choose to disclose product-fit information.

Figure 5 illustrates the proposition above. As the travel cost decreases, retailers compete more fiercely in price and disclosure helps them restore the total and retail margins. Proposition 5 shows that while the optimal disclosure policy for the seller has a threshold nature (i.e., nondisclosure for \( v \) greater than a threshold), the optimal disclosure policy for the retailer has a bell-shape nature. The intuition for the retailers’ bell-shaped disclosure strategy can be summarized as follows. When product quality is very low, disclosure helps retailers secure demand from well-matched consumers at a reasonable margin. When quality is very high, disclosure helps the retailers get a larger share of the total channel profit by making demand less elastic and hence leaving more room for retail markup. However, when
Note: When $t$ is close to zero, retailers prefer disclosure to nondisclosure for all quality levels. Quality is mediocre, the dominant effect of disclosure is to alienate ill-matched consumers, which hurts all channel members.

Overall, the retailers and seller all find a disclosure strategy optimal for low values of product quality, neither finds it optimal for intermediate values of product quality, and only the retailers find it optimal for high values of product quality.

From a substantive perspective, our results on the difference in the disclosure incentives of the seller and retailers suggest that government mandated disclosure policies (e.g., labeling requirements for textile and food) and voluntary word of mouth among consumers (e.g., third-party reviews and discussion-forum sites) may affect different channel members differently, depending on the product’s quality level. Specifically, mandatory or voluntary disclosures may benefit retailers and hurt the seller when the seller’s product quality is high, hurt all channel members when the quality is mediocre, and benefit all channel members
when quality is low.

5 Concluding Remarks

Advances in information technology and the Internet have made it cheaper and easier for a seller to disseminate product information to consumers. This paper explores the incentives of a seller to provide such information about its product to consumers to reduce their product-fit uncertainty. Our analysis shows that the disclosure of this information depends on whether the seller distributes her products through retailers, on the intensity of downstream competition, and on which channel member is in charge of the information disclosure decision. When the seller sells through highly differentiated retailers, she is less likely to disclose product-fit information when compared with selling direct. As the highly differentiated retailers are introduced in the channel, retail markup is significant, keeping the overall demand low. The high retail markup reduces the seller’s return from the margin-driving disclosure strategy, making the demand-driving nondisclosure strategy more attractive. On the other hand, if the downstream retailers are weakly differentiated and highly competitive, the seller is more likely to choose disclosure when compared with selling direct. In this case, downstream price competition leads to low retail markups, keeping the seller’s demand high. The high demand reduces the seller’s return from the use of demand-driving nondisclosure strategy, making disclosure more attractive.

When retailers are in charge of product-fit information disclosure, they choose nondisclosure only when product quality falls in an intermediate range. The dominant effect of disclosure is to secure positive demand when quality is very low, to increase the retailers’ share of total channel profit when quality is very high, and to alienate ill-matched consumers when quality is mediocre. As downstream competition gets more intense, the nondisclosure quality range shrinks as disclosure could help retailers restore the total margin and hence their own retail margins. When competition reaches a certain level, the retailers would choose disclosure for all quality levels. In general, our results suggest that retailers may ben-
efit more from disclosure than the seller when quality is high and downstream competition is intense.

As ours is the first study on the impact of a distribution channel on the pre-purchase disclosure of product-fit information, many interesting questions remain for future research. For example, if information can be collected on a consumer’s preference for stores and for the product, the seller can then customize the disclosure decision based on such information. Intuitively, consumers with a bad match to all stores and a good match to a particular product type are more likely to receive product match information. If they have a good match to a particular store, they may choose to purchase even in the absence of disclosure, and if they are not well matched to any product type, then disclosure can hardly help attract them.

The interaction of post-purchase product returns and pre-purchase information disclosure in the context of a distribution channel is another interesting direction for future research. As mentioned earlier, while pre-purchase disclosure tends to involve high fixed cost and low marginal cost, post-purchase returns are typically associated with substantial marginal cost of shipping, repackaging and salvaging of a returned product. While we have shown the impact of a distribution channel on pre-purchase disclosure, it would be interesting to further explore the impact of the reverse channel structure (e.g., who handles the returns, how the salvage value and restocking fees are divided among channel members) on pre-purchase disclosure.

We have also focused on the situation where the product types are symmetric. If product types are not symmetric and some types are more centrally located in the consumers’ taste space than others, one can expect that the popular product types may have a stronger incentive to disclose themselves while the unpopular ones have a stronger incentive to choose nondisclosure. The introduction of a distribution channel may then have differential impacts on the different types’ disclosure strategies.

Finally, we have focused our study on costless pre-purchase disclosure. When the seller has to incur positive costs in order to disclose match information, the cost is likely to push
her in the direction of nondisclosure by lowering the seller’s disclosure threshold. When the cost of disclosure is proportional to the population of informed consumers, for example, partial disclosure can only be sustained when quality becomes lower such that the reduced marginal profit from informed consumers equals the marginal profit from uninformed ones. Similarly, when disclosure is implemented by the retailers, disclosure costs may enlarge the intermediate quality range for nondisclosure.

References


Appendix

**Section 3.2.** $Z_2 = w_2 D_2$, where

\[
w_2 = \text{Root}[16 + 64t + 8t^2 + 16t^3 + t^4 - 64v - 160tv - 80t^2v - 8t^3v + 96v^2 + 128tv^2 + 24t^2v^2 - 64v^3 - 32tv^3 + 16v^4 + \#1(12t^3 - 72t^2v + 152l^2 + 144t^2v - 448tv + 304t - 96v^3 + 288v^2 - 288v + 96) + 48\#1^4 + \#1^3(80t - 160v + 160) + \#1^2(48t^2 - 192tv + 336t + 192t^2 - 384v + 192)\&c, 2].
\]

\[
D_2 = -\frac{1}{18t} \left[ t^2 + t \left( \sqrt{t^2 + 4t(-v + w + 4) + 4(-v + w + 1)^2} - 4v + 4w - 8 \right) - 2(v - w - 1) \left( \sqrt{t^2 + 4t(w - v) + 4(v - w)^2} - 4t + 2v - 2w \right) \right].
\]

**Section 3.3.** $Z_3 = w_3 D_3$, where

\[
w_3 = \text{Root}[32\#1^3 + \#1^2(52t - 80v) + \#1(108t^2 - 56tv + 64v^2) + 13t^3 - 56t^2v + 20tv^2 - 16v^3\&c, 1],
\]

\[
D_3 = \frac{1}{4} \left( \sqrt{13t^2 + 4t(w - v) + 4(v - w)^2} - 4t + 2v - 2w \right).
\]

$Z_4 = w_4 D_4$, where

\[
D_4 = \frac{2t - \frac{1}{32} \left( \sqrt{t^2 + 4t(-v + w + 12) + 4(v^2 - 2v(w + 4) + w(w + 8) + 8) + t - 2v + 2w} \right)^2}{2t}
\]

(i) for $t \leq 0.696693$, or $0.696693 < t \leq 1$ and $v > v_1 > \frac{-t^3 + t^2 + 19t + 8}{t^4 + 4t^3 + 4} \leq v < v_1$, \n
\[
w_4 = \text{Root}[128 + 192t + 36t^2 + 48t^3 + t^4 - 384v - 528tv - 232t^2v - 8t^3v + 400v^2 + 352tv^2 + 24t^2v^2 - 160v^3 - 32tv^3 + 16v^4 + \#1(12t^3 - 72t^2v + 432t^2 + 144t^2v - 1248tv + 1040t - 96v^3 + 768v^2 - 1312v + 640) + 48\#1^4 + \#1^3(80t - 160v + 512) + \#1^2(48t^2 - 192tv + 992t + 192t^2 - 1120v + 976)\&c, 2],
\]

(ii) for $0.696693 < t \leq 1$ and $\frac{-t^3 + t^2 + 19t + 8}{t^4 + 4t^3 + 4} \leq v < v_1$, \n
\[
w_4 = \text{Root}[128 + 192t + 36t^2 + 48t^3 + t^4 - 384v - 528tv - 232t^2v - 8t^3v + 400v^2 + 352tv^2 + 24t^2v^2 - 160v^3 - 32tv^3 + 16v^4 + \#1(12t^3 - 72t^2v + 432t^2 + 144t^2v - 1248tv + 1040t - 96v^3 + 768v^2 - 1312v + 640) + 48\#1^4 + \#1^3(80t - 160v + 512) + \#1^2(48t^2 - 192tv + 992t + 192t^2 - 1120v + 976)\&c, 4],
\]
with

\[ v_1 = \text{Root} \left[ 128\#1^5 + \#1^4 (432t^2 - 608t - 2192) + \#1^3 (-864t^3 - 5152t^2 + 11872t + 12896) + \right. \\
\left. \#1^2 (648t^4 + 19280t^3 + 2616t^2 - 7680t - 27824) + \right. \\
\left. \#1 (-216t^5 - 15152t^4 - 107192t^3 + 154680t^2 + 143024t + 25088) + \right. \\
\left. 27t^6 + 3434t^5 + 156139t^4 - 90856t^3 - 193004t^2 - 80512t - 8096\&. 1 \right] \\
\]

Result 3. Comparing the seller’s profit from nondisclosure and disclosure using equations (5) and (6) in the paper, we get Result 3 where

\[ v_1^I(t) = \text{Root} \left[ \#1^4 (576t^2 + 1536t + 1024) + \#1^3 (-864t^3 - 9984t^2 - 11520t - 5120) + \right. \\
\left. \#1^2 (2196t^4 + 17760t^3 + 36544t^2 + 22016t + 6400) + \right. \\
\left. \#1 (-972t^5 - 27600t^4 - 41136t^3 - 34880t^2 - 14464t - 3072) + \right. \\
\left. 117t^6 + 18288t^5 + 23032t^4 + 17984t^3 + 9616t^2 + 3072t + 512&. 1 \right] . \\
\]

\[ v_3^{II}(t) = \text{Root} \left[ \#1^6 (256t - 256) + \#1^5 (1536t^3 - 2176t^2 - 512t + 768) + \right. \\
\left. \#1^4 (2304t^5 - 8448t^4 + 1936t^3 + 4352t^2 + 384t - 960) + \right. \\
\left. \#1^3 (-3456t^6 + 9312t^5 + 8448t^4 - 6560t^3 - 3264t^2 - 128t + 640) + \right. \\
\left. \#1^2 (8784t^7 - 18288t^6 - 9312t^5 - 2112t^4 + 5208t^3 + 1088t^2 + 16t - 240) + \right. \\
\left. \#1 (-3888t^8 + 18288t^7 + 23285 - 1736t^3 - 136t^2 + 48) + 468t^9 - 4572t^6 + \right. \\
\left. 217t^3 - 4 &. 2 \right] . \\
\]

\[ v_3^{IV}(t) = \frac{1}{2} \left( t^2 + \sqrt{(t-2)(t-1)t^2 + 1} \right) . \\
\]

Proof of Lemma 2. In the disclosure subgame, a retailer’s profit is the product of his margin and demand:

\[ \pi_3^R = M_3^R \cdot D_3^R = \left\{ \begin{array}{ll} \\
\frac{2v}{9} \cdot \frac{8v^2}{81} \cdot \frac{16v^3}{729} = \frac{16v^3}{729} \quad & \text{if } 0 < v < \frac{9}{16}, \\
\frac{1}{3} \cdot \frac{1}{3} = \frac{1}{9} \quad & \text{if } \frac{9}{16} \leq v < \frac{9}{16}, \\
\frac{3}{4} + x - \frac{1}{2} \sqrt{(x-\frac{1}{2})^2 + 3} \cdot \left( -\frac{1}{2} + \frac{1}{4} + \frac{1}{2} \sqrt{(x-\frac{1}{2})^2 + 3} \right) \quad & \text{if } \frac{9}{16} \leq v < \frac{9}{16}, \\
\frac{1}{8} = \frac{1}{8} \quad & \text{if } \frac{9}{16} \leq v < \frac{9}{16}, \\
\left[ h(v) - \frac{1}{2} \right] \cdot \left[ -\frac{1}{2} h(v)^2 + \frac{3}{2} h(v) - \frac{5}{8} \right] \quad & \text{if } \frac{9}{16} \leq v < \frac{9}{16}, \\
\end{array} \right. \\
\]
where $M_R^D = p_D - w_D$, $x = v - w_D = v + 0.5 - 0.8v - \frac{3.4(−13.7 + v)(2.2 + v)}{f(v)} - 0.01f(v)$,

\[ f(v) = \left(976, 768 - 480, 768v - 301, 056v^2 - 8, 192v^3 + 85, 134(5 + v)\sqrt{(3 + v)(6 - 2v + v^2)}\right)^\frac{1}{3}, \]

and

\[ h(v) = \frac{v - w_D}{2} + \frac{1}{4} = \frac{1}{6}v - \frac{1}{6}\sqrt{(v - \frac{5}{2})^2 + 12} + \frac{13}{12}. \]

A retailer’s profit, in the nondisclosure subgame, is

\[
\pi_R^N = (p_N - w_N) \cdot D_R^N = \begin{cases} 
\frac{1}{4}(v - \frac{1}{2}) \cdot \frac{1}{4}(v - \frac{1}{2}) = \frac{1}{16}(v - \frac{1}{2})^2 & \text{if } \frac{1}{2} < v < \frac{5}{2}, \\
\frac{1}{2} \cdot \frac{1}{2} = \frac{1}{4} & \text{if } v \geq \frac{5}{2}.
\end{cases}
\]

By comparing the two profit curves, we find that the retailers’ profits are higher under disclosure if $0 < v \leq 1.28$ or $v \geq 3.77$.

- Proof of Proposition 5. When demand is in the first or second scenario in Figure 2, we can simply plot retailer profits under disclosure and nondisclosure and obtain the reputation thresholds. When demand is in the third scenario, retailer profit equals $\frac{t_4}{2}$ under nondisclosure. Meanwhile, under disclosure, as quality goes to infinity, retailer profit monotonically increases and approaches $\frac{t_2}{2}$ in the limit. Therefore, there exists $v^*$ so that the retailers would choose disclosure when $v > v^*$. 

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