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Product Fit Uncertainty and Information Provision in a Distribution Channel

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Consumers of experience goods typically face some uncertainty about the fit between their tastes and the 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. This study investigates a manufacturer's and retailers' incentives to disclose such product fit information to consumers when the manufacturer sells to consumers through competing retailers. We show that whether a manufacturer selling through retailers is more or less likely to disclose fit information compared to a manufacturer selling directly to consumers depends on the degree of retail competition. If the disclosure decisions are made before the manufacturer sets its wholesale price, then all channel members want to disclose fit information for low-quality products, no one wants to disclose it for medium-quality products, and only the retailers prefer to disclose fit information for high-quality products. This disclosure conflict for high-quality products can be resolved if the manufacturer can commit to a wholesale price before the disclosure decisions. The retailers also then prefer to not disclose fit information for high-quality products. Regardless of whether the wholesale price is set before or after disclosure decisions, a mandatory product-fit disclosure policy can decrease consumer welfare and social surplus, depending on the level of product quality and the degree of retail competition.

Key words: product fit; uncertainty; information provision; retail competition; game theory
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1. Introduction

Most consumers considering buying experience goods (Nelson 1970) have some uncertainty about the fit between their tastes and the features of products being offered. For example, a consumer may not know how well a specific stroller, magazine, eye glasses, fashion clothing, an electronic gadget, etc., will fit his specific taste. 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. 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.

For example, many magazine publishers offer electronic sample pages for consumers to "Look Inside," some skin care brands offer product samples 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. Retailers may also collect information about consumers' potential fit with the products they sell and possess the technology to convey this information to consumers. Gilt, for example, has its own in-house photo studio in Brooklyn where it shoots models wearing the items it carries.[2] Casper.com, an online retailer of mattresses, identifies 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 tastes to himself.[3] Car dealers offer test drives and offer individual consultation regarding their match with a particular car. Other commonly used online tools for manufacturers and retailers to provide such match information are multimedia descriptions of products and provision of customer reviews of products.

In all the examples, the disclosed product information reduces a consumer's uncertainty regarding his potential fit or match with the experience good.[4] Identifying how and when provision of such uncertainty-reducing disclosure benefits a firm then becomes an important managerial question. At a fundamental level, disclosure of product fit information helps a firm attract well-matched consumers and alienate ill-matched ones. Nondisclosure of product match information, in contrast, leads to more homogeneity in willingness to pay among consumers and hence a higher elasticity of demand. Thus, product-fit disclosure decision affects a seller's trade-off between its product's margin and its demand (e.g., Anderson and Renault 2006, 2009). Disclosure can then be seen as a margin-driving strategy as the product is targeted at well-matched consumers at a premium price, whereas nondisclosure can be considered a demand-driving strategy as the product is targeted to the mass market at an "average" price.

While prior research captures this basic trade-off 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 above a certain threshold (Sun 2011), no research has been done on firms' disclosure incentives when the product is sold to consumers through multiple competing retailers.[5] This gap in our understanding becomes glaring when one considers that not only the products in most of the above examples, but also in a vast number of other markets with similar product-fit related consumer uncertainties are sold in channels with competing retailers.[6] Furthermore, it is well established that degree of retail competition varies across markets and fundamentally affects important strategic choices of channel members, such as use of slotting allowance (Desai 2000, Kuksov and Pazgal 2007), choice of better demand information over inventory (Iyer et al. 2007), use of exclusive dealing to foreclose entry of a new manufacturer (Abito and Wright 2008), and use of agency selling (Abhishek et al. 2016), etc. It would, thus, be important to explicitly model disclosure in the context of a distribution channel with competing retailers to help us address important substantive questions such as the following:

(i) Does a manufacturer have more or less incentive to disclose product-fit information when it sells through competing retailers rather than directly?
(ii) If the retailers can also disclose product-fit information to consumers, when would their incentives to disclose align with the manufacturer's incentive?
(iii) What would be the equilibrium disclosure outcome of a distribution channel if both the manufacturer and the retailers can disclose product-fit information?
(iv) Would a mandatory product-fit disclosure policy by some external agency be beneficial to consumers and society?
(v) How would the answers to the above questions depend on whether the product-fit disclosure decision is taken before or after the manufacturer sets its wholesale price, and on the degree of retail competition?

The goal of this study is to address these questions using a model in which a monopolist manufacturer 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.

Use of this modeling framework allows us to contribute the following four main new results to the literature. First, it shows that there is no one direction in which selling through retailers, rather than directly, affects a manufacturer's disclosure incentive. A manufacturer could become more likely to disclose or less likely to disclose, depending on the degree of retail competition. Second, if the disclosure decisions are made before the manufacturer sets its wholesale price, then there exist both a zone of conflict and a zone of no-conflict between manufacturer and retailers in their disclosure incentives. Specifically, the manufacturer and the retailers all want to disclose product match for products of low quality and not disclose it for products of medium quality. However, for high-quality products, only the retailers, and not the manufacturer, want to disclose product match information. Third, we show that if the manufacturer can commit to a wholesale price before disclosure decisions are made, then it can better align the retailers' disclosure incentive with its own. Specifically, the retailers can be made to no longer find it optimal to disclose match information for high-quality products, which is what the manufacturer prefers. Fourth, regardless of whether wholesale price is set before or after disclosure decisions, a mandatory product-fit disclosure policy can either increase or decrease consumer welfare and social surplus, depending on the level of product quality and the degree of retail competition.

In terms of managerial relevance of our results, the first takeaway for a manufacturer is the awareness that, for certain products qualities and degrees of retail competition, retailers would make product-fit disclosure decisions that hurt the manufacturer. Second, and importantly, the manufacturer should know that it can commit to appropriate wholesale prices in many such cases (e.g., for high-quality products) to incentivize retailers to make disclosure decisions consistent with the manufacturer's wishes. From a public policy perspective, the main takeaway is that mandating product-fit disclosure, when a manufacturer sells through competing retailers, may actually end up hurting consumer and social surplus.

Relationship to Literature. 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 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 consumers' 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 match disclosure occurs when quality is low and that the unraveling 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., Anderson and Renault 2009, Gu and Xie 2013, Shaffer and Zettelmeyer 2004). In contrast to these studies, our study examines disclosure of product match information in the context of a distribution channel with competing retailers.

The two other studies that examine fit revelation in a distribution channel are Gu and Liu (2013) and Hao and Tan (2019). Gu and Liu (2013) 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.

Hao and Tan (2019) consider a market in which a manufacturer sells through a single retailer, and examine how an agency pricing contract vs. a wholesale pricing contract affects the benefits the manufacturer and retailer get from consumers knowing the distribution of their product valuations better. The paper shows how channel costs and the spread of consumer product valuations determine these benefits. Our paper differs from this paper in multiple regards. The primary difference is that while Hao and Tan do not model retail competition and focus on variables such as channel members' marginal costs, we model retail competition and examine its effect on disclosure decisions. Modeling retail competition is important not only because many, if not most, real-world distribution channels can be characterized by an oligopolistic retail sector, but also because it can change the insights one gets from a model with a single retailer. Broadly, the degree of retail competition, through its direct and strategic effects on channel members' margins and demands, influences channel members' relative returns from demand-driving nondisclosure policies and margin-driving disclosure policies, and thus affects their equilibrium product-fit disclosure decisions.

For example, in our setup, a single-retailer model predicts that a manufacturer would use nondisclosure policy for a high-quality product, but a competing-retailer model shows that the manufacturer would instead use disclosure policy for the same-quality product if retail competition is sufficiently high. Similarly, conclusions about whether and when mandatory disclosure policies by the government help consumer and social welfare also differ depending on the degree of retail competition. Finally, while Hao and Tan analyze the case where the disclosure decision is made before the wholesale price is set in a wholesale pricing model, we also examine the case where the wholesale price is set before disclosure decisions. Examination of these alternate timelines allows us to show how a manufacturer's ability to commit to a wholesale price first can help it align its retailers' disclosure incentives with its own in many cases.

Less related to our paper is the vast literature on the disclosure of product quality. In their seminal papers, Grossman (1981) and Milgrom (1981) establish the unraveling 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 (Guo 2009, Guo and Zhao 2009, Jovanovic 1982), consumer's uncertainty about their preference for quality and asymmetry in firms' quality levels (Kuksov and Lin 2010), whether disclosure is simultaneous or sequential (Guo and Zhao 2009), and whether disclosure is made directly to consumers or through downstream retailers (Guo 2009). In contrast to this body of work that focuses on the disclosure of product quality, 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 part of the uncertainty in consumers' valuations of a product comes from the idiosyncratic match.

Figure 1 summarizes the positioning of our paper relative to the key relevant papers on seller's product information disclosure to consumers.

Another stream of related literature is the one on product returns (e.g., Ofek et al. 2011, Shulman et al. 2009). 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. Pre-purchase disclosure is often implemented through digital technologies with high fixed cost and low marginal cost, while 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, 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.

Finally, there is a rich literature that examines information-sharing incentives among firms in distribution channels. For example, Li (2002) analyzes incentives of retailers competing in quantities to share their private demand and cost information with their common upstream manufacturer; Zhang (2002) studies such incentives when retailers compete in prices or quantities and when products can be substitutes or complements; Shang et al. (2016) examine the information-sharing incentive for a common retailer that sells products from two competing upstream manufacturers; Gal-Or et al. (2008) and Mishra et al. (2009) study incentives of a retailer and a manufacturer to share with each other their private demand information. In contrast to this stream of literature, our focus is on examining the incentives of the manufacturer and retailers to share their information about product features with consumers.

Figure 1 Some Key Papers on Seller's Product Information Disclosure to Consumers

	No Downstream Retailer	*Monopoly Downstream Retailer*	*Oligopolistic Downstream Retailers*
Consumer uncertainty about product quality	- Kuksov and Lin (2010) - Guo and Yang (2009)	- Guo (2009)	
Consumer uncertainty about product match	- Anderson and Renault (2006, 2009) - Chen and Xie (2008) - Sun (2011) - Gu and Xie (2013)	- Gu and Liu (2013) - Hao and Tan (2019) - **This paper**	**- This paper**

The remainder of the paper is organized as follows. In the next section, we set up our model. Section 3 presents a benchmark case in which the manufacturer sells directly to consumers. Section 4 analyzes disclosure decisions in a channel in which the manufacturer sells through a monopolistic retailer. In section 5, we examine disclosure decisions in a channel in which the manufacturer sells through two competing retailers. Section 6 reexamines the results from sections 4 and 5 under an alternative decision timeline: disclosure decisions made after the manufacturer's wholesale price is set. Section 7 concludes with a discussion of limitations of some of the assumptions in the current model, and ideas for possible extensions.

2. The Model

There is a seller (manufacturer) who 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 preferences 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. 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.

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 product types. The two stores in our model are located at $x_s = 0$ and $x_s = 1$, and the store locations are common knowledge. They can be jointly owned by the manufacturer 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 manufacturer'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 location 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:

$$\begin{aligned} u(x, y) &\equiv \frac{U(x, y)}{t_y} = \frac{v - p - t_x \cdot x - t_y \cdot y}{t_y} \\ &\equiv v' - p' - t \cdot x - y, \end{aligned}$$

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 $t = t_x$.[7]

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 do consumers care about the difference between retailers, and the more intense is downstream retail competition. Conceptually, the travel cost parameter captures the retailers' market power against the manufacturer as it reflects how much the consumers care about retailer characteristics. We assume $t \in (0,1]$ so that retailers may find it optimal to compete in equilibrium. In the real world, there are often more than two retailers, some more differentiated than others.

While other variables in the consumer's utility function are common knowledge, the product's type, and hence the product's fit with consumers, is not known to consumers, retailers, or the manufacturer. The manufacturer and the retailers may, however, enable the consumers to learn this information. To keep the analysis tractable, we assume that the disclosure cost is zero. In reality, there are often fixed costs that are associated with setting up a disclosure mechanism. Such fixed costs, however, are rarely incurred for a single product. Instead, a manufacturer or retailer usually sells many different products and hence when we think of the disclosure incentives for a particular product, the disclosure mechanism tends to be already available. We assume that if the manufacturer or retailers choose disclosure, 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.[8]

3. Benchmark Case of Manufacturer Selling Directly to Consumers

In this benchmark case, the manufacturer owns both stores and sells directly to consumers. The timeline is as follows. First, the manufacturer decides whether to enable consumers to learn the product's location ($y_p = 0$ or $y_p = 1$). She then sets a price p and each consumer decides whether to buy the product.[9]

The timeline of the game fits real-world scenarios in which manufacturer disclosure is hard to reverse. For example, IKEA has large stores in which consumers can see and try its home products and building a store entails significant costs. Some skin care brands offer their products in sample-size packaging for consumers to try on, and they need to commit to producing such packaging. Certain book publishers offer parts of their books as free sample pages for consumers to read online before making a purchase decision, and the pages need to be scanned carefully beforehand. Such information-revelation mechanism involves substantial investment and is harder to change than price. Once the mechanism is in place, however, the cost of disclosure for an additional product is zero.

Similarly, when retailers making disclosure decisions (examined later in the paper), they may also have to invest in costly information-revelation mechanisms that demonstrate serious commitment. For example, Gilt set up its own photo studio to offer better product pictures online. Offline retailers hire experienced sales forces to do in-store demonstrations of their products and answer questions about product features.

We solve the game backward by comparing the manufacturer's profit levels in the disclosure and nondisclosure subgames. As a tie-breaking rule, we assume throughout the paper that a channel member chooses nondisclosure when it is indifferent between disclosure and nondisclosure. This benchmark case of direct selling is solved in the Appendix since it replicates the results in Sun (2011). Our contribution is in introducing and examining the effects of presence of retailer(s) on channel members' incentives to disclose product fit information to consumers, which we examine in detail in the rest of the paper.

BENCHMARK. *A manufacturer selling directly to consumers chooses to provide product-fit information iff* $v < v^D(t)$, *where* $v^D(t) =$ *(i)* $2 + \frac{t}{4} - \sqrt{2-t}$ *for* $0 \le t < \frac{2}{9}$, *and (ii)* $\frac{1}{2} + \frac{t}{4} + \frac{\sqrt{2t}}{4}$ *for* $\frac{2}{9} \le t \le 1$.

Thus, the manufacturer has a stronger incentive to disclose the product's match with the consumers when the product quality is low. Intuitively, when product quality is low, most consumers are not interested in it and match disclosure in this case helps the manufacturer secure demand from the well-matched consumers. When product 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 would be to drive away less-matched consumers, and hence the manufacturer prefers not to engage in match disclosure.

4. Manufacturer Selling through a Monopolistic Retailer

We next consider the case where the manufacturer distributes her product through a monopolistic retailer who owns both stores. The timeline is as follows: the manufacturer and the retailer first decide whether to enable the consumers to learn the product type. The manufacturer then sets her wholesale price w to the retailer, and the retailer then sets its retail price p. Finally, each consumer decides whether to buy the product. We also analyze the retailer's disclosure incentive in section 4.2 in a scenario where the retailer, rather than the manufacturer, can choose to enable the disclosure of product type before the manufacturer sets her wholesale price.

4.1. Manufacturer's Benefit from Fit Disclosure

No-Disclosure Case. 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, there are three possible demand scenarios: no demand, partial market coverage, and full market coverage. Figure 2 shows these cases.

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

Knowing the optimal pricing strategy of the retailer, the manufacturer chooses the wholesale price w to maximizes her profit. If she charges a high wholesale price so that the retailer does not cover the entire market, the manufacturer's profit is $w \cdot \frac{2}{t} \cdot (v - p^* - \frac{1}{2})$, 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 together all these scenarios, the manufacturer's optimal price w^*, retail price p^*, sales d^*, and profit π^M_{ND} are:

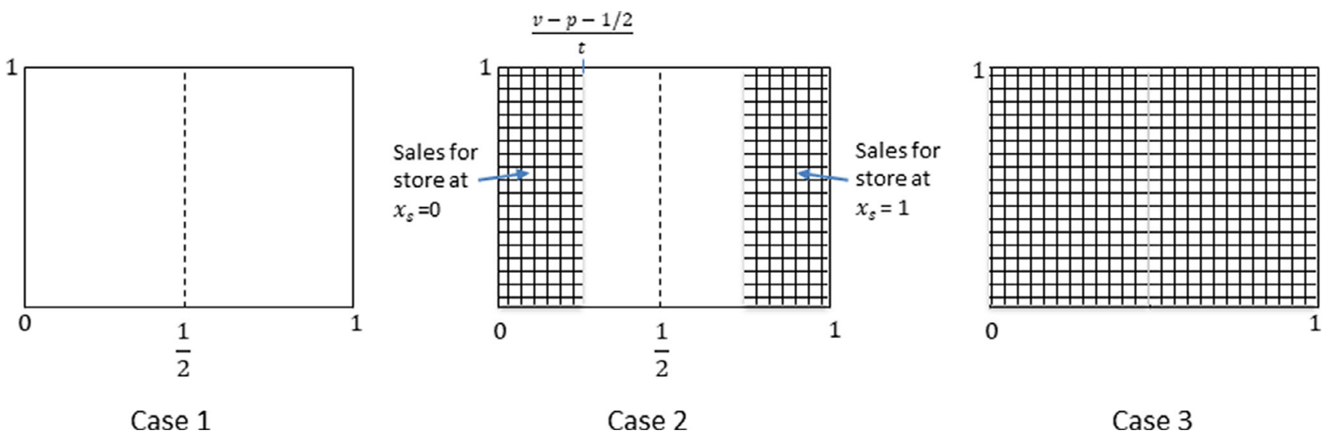
(i) If $0 < v < \frac{1}{2}$, no sales;
(ii) If $\frac{1}{2} \le v < 2t + \frac{1}{2}$, $w^* = \frac{2v-1}{4}$, $p^* = \frac{3(2v-1)}{8}$, $d^* = \frac{2v-1}{4t}$, $\pi^M_{ND} = \frac{(2v-1)^2}{16t}$;
(iii) If $v \ge 2t + \frac{1}{2}$, $w^* = \frac{2(v-t)-1}{2}$, $p^* = \frac{2v-t-1}{2}$, $d^* = 1$, $\pi^M_{ND} = v - t - \frac{1}{2}$.

Thus, as product quality increases, the manufacturer is able to charge a higher wholesale price, and market coverage also increases until the whole market is covered. As a result, the manufacturer's profit increases in its product quality.

Disclosure Case. 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, there are five possible demand scenarios. Figure 3 shows them in the order of increasing market coverage.

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 $p - w$,

Figure 2 Nondisclosure Subgame [Color figure can be viewed at wileyonlinelibrary.com]



and the optimal retail price is $\frac{1}{3}(v+2w)$. In this demand scenario, the manufacturer maximizes her profit by charging $w_D = \frac{v}{3}$. For the two stores to remain local monopolies, the demand for each retailer must be smaller than $\frac{t}{4}$, which implies $v < \frac{9t}{8}$.

In the second demand scenario, the demand is $v - p - \frac{t}{4}$; in the third, it is $\frac{v-p}{2}$; in the fourth case, it is $\frac{3-t}{2}$; and in the fifth scenario, the demand is $1 - \frac{(2(v-p-1-t/2)^2}{4t}$. Following the same steps as before, we solve for the optimal prices in each demand scenario, and summarize the equilibrium manufacturer price w^*, retailer price p^*, sales d^*, and profit π_D^M below:

(i) If $0 < v < \frac{9t}{8}$, $w^* = \frac{v}{3}$, $p^* = \frac{5v}{9}$, $d^* = \frac{16v^2}{81t}$, $\pi_D^M = \frac{16v^3}{243t}$;
(ii) If $\frac{9t}{8} \le v < \frac{5t}{4}$, $w^* = \frac{4v-3t}{4}$, $p^* = \frac{2v-t}{2}$, $d^* = \frac{t}{4}$, $\pi_D^M = \frac{(4v-3t)t}{16}$;
(iii) If $\frac{5t}{4} \le v < \frac{16-3t}{4}$, $w^* = \frac{4v-t}{8}$, $p^* = \frac{3(4v-t)}{16}$, $d^* = \frac{4v-t}{16}$, $\pi_D^M = \frac{(4v-t)^2}{128}$;
(iv) If $\frac{16-3t}{4} \le v < \frac{16+24t-5t^2}{8t}$, $w^* = \frac{4v-8+t}{4}$, $p^* = v-1$, $d^* = \frac{4-t}{4}$, $\pi_D^M = \frac{(4v+t-8)(4-t)}{16}$;
(v) If $v \ge \frac{16+24t-5t^2}{8t}$, the expressions of w^*, p^*, d^*, and π_D^M get quite complex, and are presented in the Appendix.

Thus, the manufacturer is able to charge a higher price for a product of higher quality and the market coverage also weakly increases in product quality. Overall, the manufacturer's profit increases in its product quality.

Comparing the manufacturer's profits under disclosure and nondisclosure, we find that the manufacturer benefits from disclosure if $v < v^{MR}(t)$, with superscript MR representing Monopolistic Retailer, and

$$v^{MR}(t) = \begin{cases} 4-\sqrt{6(2-t)}+\frac{t}{4} & \text{for } 0 \le t < 0.0408; \\ \frac{1}{4}(2+t+\sqrt{2t}) & \text{for } 0.0408 \le t < 0.82; \\ \frac{1}{2}(1+t^2+t\sqrt{2-(3-t)t}) & \text{for } 0.82 \le t < 0.9425; \\ 1.06 & \text{for } 0.9425 \le t < 1. \end{cases} \quad (1)$$

Comparing this threshold $v^{MR}(t)$ to the benchmark direct-selling threshold $v^D(t)$ from section 3, we get our first main result.

Proposition 1. *A manufacturer selling through a monopolistic retailer is less likely to enable the disclosure of product fit information than a manufacturer selling directly to consumers.*

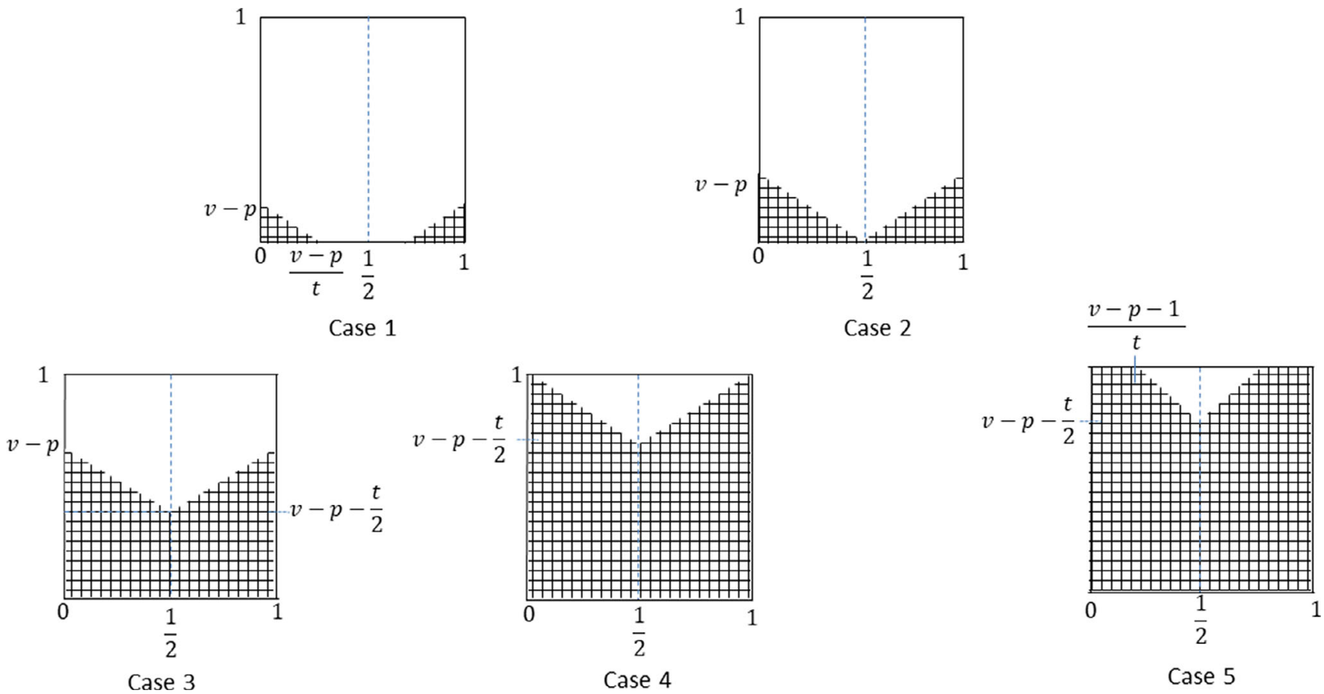
The intuition is as follows. When the manufacturer sells through a monopolistic retailer, double marginalization leads to a positive markup for the retailer, which reduces the total channel profit and shifts some of the channel profit to the retailer. The manufacturer can then limit its loses using nondisclosure strategy that increases homogeneity in consumer willingness to pay, making the demand more elastic, and thus reducing retailer markup.

4.2. Monopolistic Retailer's Benefit from Fit Disclosure

When does the retailer benefit from disclosure of product fit information? Using the optimal prices derived in the previous Section, we get the retailer margin m^*, sales d^*, and profit π_{ND}^R in the nondisclosure case as

(i) If $0 < v < \frac{1}{2}$, no sales;
(ii) If $\frac{1}{2} \le v < 2t + \frac{1}{2}$, $m^* = \frac{2v-1}{8}$, $d^* = \frac{2v-1}{4t}$, $\pi_{ND}^R = \frac{(2v-1)^2}{32t}$;
(iii) If $v \ge 2t + \frac{1}{2}$, $m^* = \frac{t}{2}$, $d^* = 1$, $\pi_{ND}^R = \frac{t}{2}$.

Figure 3 Disclosure Subgame [Color figure can be viewed at wileyonlinelibrary.com]



Thus, retailer's margin and profit increase in product quality when the market is not fully covered, and become independent of product quality when the market is fully covered. Intuitively, when the market is fully covered, demand is completely inelastic, and a manufacturer desiring to keep the market covered only needs to leave enough margin for the retailer (here $\frac{t}{2}$) so that it is willing to serve the whole market.

Similarly, for the disclosure case, we use the optimal prices derived in the previous Section to get the retailer margin m^*, sales d^*, and profit π_D^R as follows:

(i) If $0 < v < \frac{9t}{8}$, $m^* = \frac{2v}{9}$, $d^* = \frac{16v^2}{81t}$, $\pi_D^R = \frac{32v^3}{729t}$;
(ii) If $\frac{9t}{8} \le v < \frac{5t}{4}$, $m^* = \frac{t}{4}$, $d^* = \frac{t}{4}$, $\pi_D^R = \frac{t^2}{16}$;
(iii) If $\frac{5t}{4} \le v < \frac{16-3t}{4}$, $m^* = \frac{4v-t}{16}$, $d^* = \frac{4v-t}{16}$, $\pi_D^R = \frac{(4v-t)^2}{256}$;
(iv) If $\frac{16-3t}{4} \le v < \frac{16+24t-5t^2}{8t}$, $m^* = \frac{4-t}{4}$, $d^* = \frac{4-t}{4}$, $\pi_D^R = \frac{(4-t)^2}{16}$;
(v) If $v \ge \frac{16+24t-5t^2}{8t}$, the expressions of m^*, p^*, and π_D^R become complex and are presented in the Appendix.

We note again that the retailer's margin, market coverage, and profit all increase weakly in product quality. Comparing the retailer's profits from the disclosure and nondisclosure subgames, we find that the retailer benefits from disclosure if

$$\begin{array}{ll} v>0 & \text{for } 0\le t<0.0408; \\ v<\frac{1}{4}(t+\sqrt{2t}+2) \text{ or } v>\frac{1}{4}(t+8\sqrt{2t}) & \text{for } 0.0408\le t<0.82; \\ v<\frac{1}{2}(1+t^2\sqrt{2t}) \text{ or } v>\frac{1}{4}(t+8\sqrt{2t}) & \text{for } 0.82\le t<1. \end{array} \tag{2}$$

Thus, we have the following result.

Proposition 2. *If a manufacturer sells through a monopolistic retailer, then the retailer benefits from the disclosure of product fit information (i) for products of all quality if $t \in (0,0.0408)$, and (ii) if $t \in [0.0408,1]$, then for products of either sufficiently low or sufficiently high quality, and not for products of intermediate quality.*

Intuitively, when travel cost t is extremely small ($t < 0.0408$), consumer demand is extremely elastic, making the retailer's markup miniscule. Nondisclosure in this case, by making the consumer demand even more elastic (increased homogeneity in consumer valuation), reduces this miniscule retail margin even further. Disclosure, on the other, decreases homogeneity in consumer valuation, making it less elastic, and allows retailer to get more margin and profit. Thus, irrespective of the level of product quality, the retailer in this case never benefits from nondisclosure.

For the other values of travel cost, $t \in [0.0408,1]$, nondisclosure can sometimes benefit the retailer, depending on how product quality affects the decrease in its margin and the increase in its demand. When product quality is low, nondisclosure does not increase demand much since willingness to pay is low; in fact, nondisclosure leads to zero demand when the willingness to pay is lower than the expected misfit cost. When product quality is high, nondisclosure again does not increase demand much since willingness to pay is so high that market is almost or fully covered. When the product quality is intermediate, nondisclosure increases the retailer's demand significantly.

Regarding the retailer, nondisclosure reduces retail margin significantly when product quality is low, as willingness to pay could be so low that nondisclosure may lead to zero demand and hence no retail margin. When product quality is high, nondisclosure again leads to a large reduction in retail margin since nondisclosure implies forfeiting the large margin that well-matched consumers are willing to pay for high-quality products. When product quality is high enough, nondisclosure leads to a fully covered market, allowing the manufacturer to leave the retailer with just enough margin, $t/2$, to make the retailer continue finding it optimal to sell to the whole market. Finally, when the product quality is intermediate, nondisclosure does not decrease retail margin much.

Overall, when product quality is sufficiently low or sufficiently high, nondisclosure hurts the retailer since it leads to a small demand increase and a large margin decrease. When product quality is intermediate, nondisclosure benefits the retailer since it leads to a large demand increase and a small margin decrease. Figure 4 illustrates these trade-offs for $t = 1$.

4.3. Product-Fit Disclosure in the Channel

Now consider the case where both the manufacturer and the retailer can enable the disclosure of product fit information to consumers. Keeping the same time-line as before (i.e., disclosure decision before pricing), we can use Propositions 1 and 2 to find equilibrium disclosure outcomes in a channel.

PROPOSITION 3. *If a manufacturer sells through a monopolistic retailer, and both are deciding whether to disclose product fit information, then* (*i*) *the retailer and manufacturer share the incentive to disclose fit information for products of sufficiently low quality;* (*ii*) *only the retailer has the incentive to disclose fit information for products of sufficiently high quality; and* (*iii*) *neither the manufacturer nor the retailer has an incentive to disclose fit information for products of intermediate quality.*

Figure 5 shows this result graphically.

Putting together all the results from this Section, we reach the following conclusions. If only a manufacturer is disclosing fit information, then disclosure becomes less likely when the product is sold through a retailer compared to when it is sold directly. If both the manufacturer and the retailer are disclosing fit information, then disclosure becomes more likely when the product is sold through a retailer compared to when it is sold directly. Specifically, the retailer would disclose fit information for high-quality products, while the manufacturer would not if it were selling directly. Finally, for products of intermediate product quality, neither the manufacturer nor the retailer benefits from disclosing fit information. Therefore, whether a manufacturer sells directly or through a retailer, fit information for products of intermediate quality does not get disclosed.

Can Total Channel Profit Maximization Goal Lead to More Disclosure? Proposition 3 above shows that individual profit maximization goal does not incentivize either the manufacturer or the retailer to disclose product fit information for products of intermediate product quality. One may wonder whether total channel profit maximization would lead to disclosure of fit information for such intermediate-quality products.[10]

Comparing total channel profits in the disclosure vs. nondisclosure scenarios, we find that the answer is in the negative. The channel as a whole benefits from disclosure of fit information only for products of sufficiently low quality, with the following quality threshold:

$$v < \begin{cases} \frac{1}{12}(32 + 3t - 8\sqrt{10 - 3t}) & \text{for } 0 \le t < 0.0408; \\ \frac{1}{4}(2 + t + \sqrt{2t}) & \text{for } 0.0408 \le t < 0.82; \\ \frac{1}{2} + \frac{1}{3}t^2 + \frac{1}{3}t\sqrt{3 + (t-3)t} & \text{for } 0.82 \le t < 1. \end{cases}$$

Noting that this disclosure threshold is very close to the one based on only manufacturer's profit maximization goal, we can infer that nondisclosure of fit information for intermediate-quality products is not causing much distortion in the channel. In other words, nondisclosure of fit information for products of intermediate quality remains the outcome whether channel members maximize their individual profits or the total channel profit.

Welfare Effects of Mandatory Disclosure Policy. Proposition 3 above shows that individual profit

Figure 4 Retailer Outcomes under Disclosure and Nondisclosure [Color figure can be viewed at wileyonlinelibrary.com]

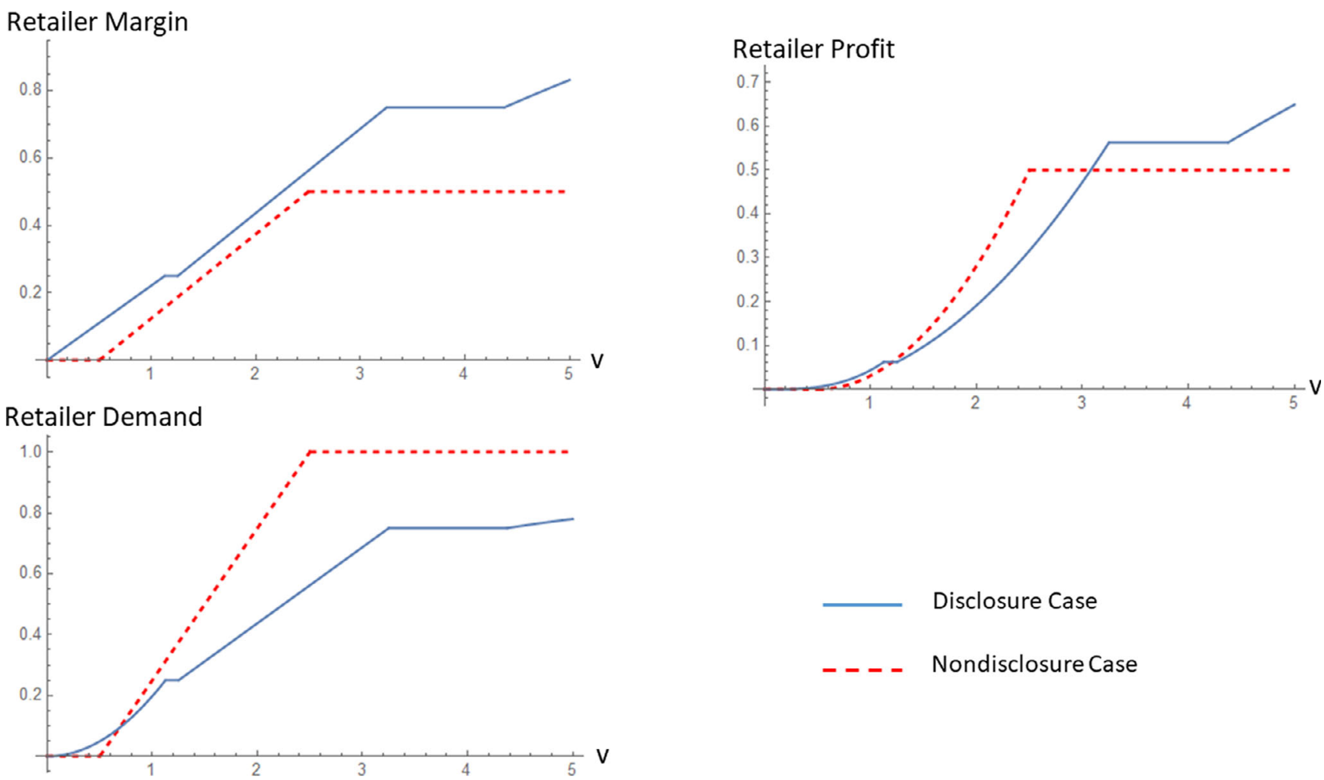
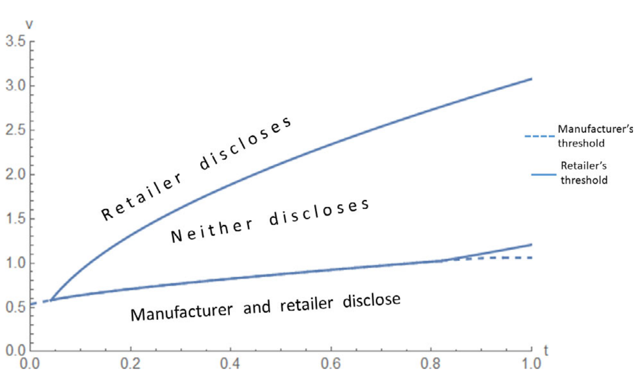


Figure 5 Product Fit Disclosure in a Channel with a Monopolistic Retailer [Color figure can be viewed at wileyonlinelibrary.com]



maximization leads channel members to disclose product-fit information on their own for products of sufficiently low and sufficiently high qualities, but not for products of intermediate quality. Thus, if some external agency were to mandate product-fit disclosure, there would be no effect of that policy on consumer surplus for products of sufficiently low or sufficiently high qualities, and the policy would indeed change consumer welfare by moving them from a nondisclosure regime to a disclosure regime for products of intermediate quality.

Using the optimal prices and sales shown under disclosure and nondisclosure cases earlier in this Section, we calculate the consumer and social surplus in the Appendix, and find that a mandatory product-fit disclosure policy can either increase or decrease consumer and social surplus. Intuitively, consumer surplus can reduce from mandatory disclosure policy because although mandatory disclosure helps decrease the expected product-misfit cost borne by consumers, it does allow the firms to charge higher prices from consumers with better fit. Social welfare can then also reduce because the mandatory disclose policy comes into effect when firms themselves do not find it profitable to disclose.

5. Manufacturer Selling through Competing Retailers

In this Section, we examine the effect of downstream retail competition on product-fit disclosure incentives of channel members.

Consider a situation in which the manufacturer 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. Finally, to acknowledge the fact that information-sharing among consumers becomes easier over time, we assume that the choice of disclosure from a single retailer is sufficient for all consumers to learn the product's location.

5.1. Manufacturer's Benefit from Fit Disclosure

No-Disclosure Case. In this case, the two retailers select their prices to maximize their profit over the possible demand scenarios shown in Figure 2, and the manufacturer takes that into account while setting its prices as the Stackelberg leader.

When the two retailers remain local monopolies (case 2 in Figure 2), the optimal retail 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 the two retailers compete and the market is completely covered (case 3 in Figure 2), 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 $t + \frac{1}{2} \le v - w \le \frac{3}{2}t + \frac{1}{2}$, the retailers cover the entire market and yet do not compete with each other, that is $p_A^* = p_B^* = v - \frac{1}{2} - \frac{t}{2}$.

The manufacturer takes these retailers' pricing strategies into account when setting the wholesale price w to maximize her profit. We get the manufacturer's profit as:

(i) If $0 < v < \frac{1}{2}$, no sales;
(ii) $\frac{(2v-1)^2}{16t}$ if $\frac{1}{2} \le v < 2t + \frac{1}{2}$; and
(iii) $v - t - \frac{1}{2}$ if $v \ge 2t + \frac{1}{2}$.

Disclosure Case. In this case, the two retailers select their prices in order to maximize their profit over the five possible demand scenarios shown in Figure 3. Following the same steps as before, we solve for the optimal price in each demand scenario. Comparing the manufacturer's profit across all possible scenarios for each level of product quality, we obtain the manufacturer's maximum profit as follows:

(i) $\frac{16v^3}{243t}$ for $0 < v < \frac{9t}{8}$;
(ii) $\frac{(4v-3t)t}{16}$ for $\frac{9t}{8} \le v < \frac{19t}{16}$;
(iii) Z_2 for $\frac{19t}{16} \le v < \frac{-3t^3+10t^2+22t+16}{2t^2+8t+8}$;
(iv) $\frac{(4-t)(t^2+2(t+2)v-6t-4)}{8(t+2)}$ for $\frac{-3t^3+10t^2+22t+16}{2t^2+8t+8} \le v < \frac{-t^3+t^2+19t+8}{t^2+4t+4}$; and
(v) Z_3 for $v \ge \frac{-t^3+t^2+19t+8}{t^2+4t+4}$, where the long expressions of Z_2 and Z_3 are presented in the Appendix.

Comparing the manufacturer's profits under disclosure and nondisclosure, we find that the manufacturer benefits from disclosure if $v < v^{CR}(t)$, with superscript CR representing Competitive Retailers, and the long expression of $v^{CR}(t)$ is presented in the Appendix.

Noting that the threshold $v^{CR}(t)$ is increasing in t, we get the following result.

Proposition 4. *If a manufacturer sells through competing retailers, then an increase in retailer differentiation, as captured by an increase in travel cost t, makes the manufacturer more likely to disclose product fit information.*

Two effects drive this key result. First, in this model, consumers' net willingness to pay for the product decreases as travel cost t increases. The use of nondisclosure here would further reduce the lowered consumer willingness to pay, hurting the manufacturer. Second, as t increases, retailers face weaker competition from each other, have increased markups, and consumer demand becomes less elastic. This reduces the effectiveness of nondisclosure strategy in expanding demand. Overall, the manufacturer benefits more from fit disclosure when retailers are more differentiated.

Next, comparing the threshold $v^{CR}(t)$ to the benchmark direct-selling threshold $v^D(t)$ from section 3, we find that $v^{CR}(t) \gtrless v^D(t)$ for $t \lessgtr 0.855$. Thus, we get the following result:

Proposition 5. *Compared to the case where a manufacturer sells directly to consumers, if the manufacturer sells through two competing retailers, then she is (i) more likely to disclose product fit information if the retailers are less differentiated, and (ii) less likely to disclose product fit information if the retailers are more differentiated.*

First, whether the manufacturer sells directly or through competing retailers, it chooses the disclosure strategy for products of very low qualities, $q < \min\{v^D(t), v^{CR}(t)\}$ to get adequate margin, and the nondisclosure strategy for products of very high qualities, $q \geq \max\{v^D(t), v^{CR}(t)\}$ to expand its demand. However, for products that do not have those extreme qualities, the degree of retailer differentiation determines whether a manufacturer selling through retailers is more or less likely to use disclosure strategy compared to a manufacturer that sells to consumers directly. The intuition is as follows.

Compared to selling direct, the manufacturer selling through retailers incurs a loss in both her margin and demand. The relative magnitudes of these losses are influenced by the degree of retailer differentiation, and determines how the manufacturer's disclosure policy changes as it moves from selling direct to selling through retailers. When retailers are less differentiated, they compete aggressively on retail prices, leading to low retail markups, keeping the demand relatively high. This high demand (less-reduced demand) reduces the returns from demand-driving nondisclosure strategy and makes the margin-driving disclosure strategy more attractive. When retailers are more differentiated, they have market power which they use to charge a high markup, keeping the demand low. This low demand (more-reduced demand) reduces the returns from margin-driving disclosure strategy and makes the demand-driving nondisclosure strategy more attractive.

5.2. Competing Retailers' Benefit from Fit Disclosure

Using the demand situations for the nondisclosure case from the last Section, we get each retailer's profit under nondisclosure as

(i) If $0 < v < \frac{1}{2}$, no sales;
(ii) $\frac{(2v-1)^2}{64t}$ if $\frac{1}{2} \leq v < 2t + \frac{1}{2}$; and
(iii) $\frac{t}{4}$ if $v \geq 2t + \frac{1}{2}$.

Similarly, using the demand for the disclosure case from the last Section, we get each retailer's profit under disclosure as

(i) $\frac{16v^3}{729t}$ for $0 < v < \frac{9t}{8}$;
(ii) $\frac{t^2}{32}$ for $\frac{9t}{8} \leq v < \frac{19t}{16}$;
(iii) Z_4 for $\frac{19t}{16} \leq v < \frac{-3t^3+10t^2+22t+16}{2t^2+8t+8}$;
(iv) $\frac{(4-t)^2 t}{16(t+2)}$ for $\frac{-3t^3+10t^2+22t+16}{2t^2+8t+8} \leq v < \frac{-t^3+t^2+19t+8}{t^2+4t+4}$; and
(v) Z_5 for $v \geq \frac{-t^3+t^2+19t+8}{t^2+4t+4}$,

where the long expressions of Z_4 and Z_5 are presented in the Appendix.

Comparing the retailers' profits from the disclosure and nondisclosure subgames given above, we find that the retailers benefit from disclosure if $v < v_L^{CR}(t)$ or $v > v_H^{CR}(t)$, where the long expressions of $v_L^{CR}(t)$ and $v_H^{CR}(t)$ are presented in the Appendix. This allows us to get the following result.

PROPOSITION 6. *If a manufacturer sells through two competing retailers, then the retailers benefit from disclosure of product fit information for products of either sufficiently low or sufficiently high qualities, and not for products of intermediate quality.*

Intuitively, nondisclosure can sometimes benefit the retailers, depending on how product quality affects the magnitudes of the decrease in their margin and the increase in their demand. When product quality is low, willingness to pay is low, and nondisclosure does not increase demand much and yet decreases retailer margin significantly. Similarly, when product quality is high, nondisclosure does not increase demand much since market is almost or fully covered, and it decreases retail margin significantly. However, when product quality is intermediate, nondisclosure benefits the retailers since it leads to a large demand increase and a small margin decrease.

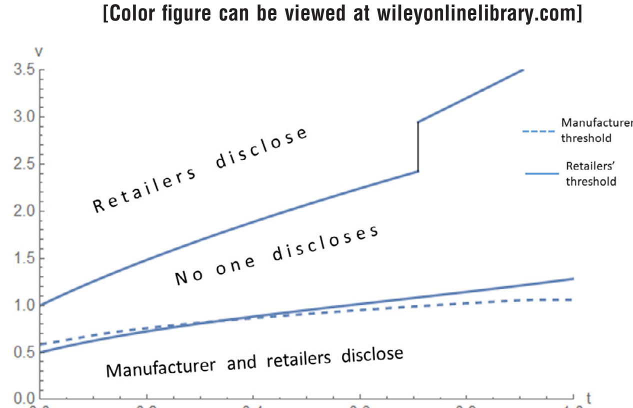
5.3. Product-Fit Disclosure in Channel

Consider the case where both the manufacturer and the retailers can both enable the disclosure of product match information to consumers. Using Propositions 4 and 5, we get the following equilibrium disclosure outcome.

PROPOSITION 7. *If a manufacturer sells through two competing retailers, and all are deciding whether to disclose product fit information, then*

(*i*) *the manufacturer has an incentive to disclose fit information for sufficiently low-quality products;*
(*ii*) *the retailers have an incentive to disclose fit information for both sufficiently low-quality and sufficiently high-quality products;*

Figure 6 Product Fit Disclosure in a Channel with Competing Retailers [Color figure can be viewed at wileyonlinelibrary.com]



(*iii*) *no one has an incentive to disclose product fit information for products of intermediate quality.*

Thus, the equilibrium disclosure outcome in a channel with competing retailers is qualitatively similar to that in a channel with a monopolistic retailer. There is no disclosure of fit information for products of intermediate quality. Figure 6 shows this result graphically.[11]

Welfare Effects of Mandatory Disclosure Policy. As in the case of a monopolistic retailer, individual profit maximization leads channel members to disclose product-fit information on their own for products of sufficiently low and sufficiently high qualities, but not for products of intermediate quality. Thus, a mandatory product-fit disclosure policy can affect welfare for products of intermediate quality by moving the system from a nondisclosure regime to a disclosure regime. We calculate the consumer and social surplus in the Appendix, and find that a mandatory product-fit disclosure policy can either increase or decrease consumer and social surplus. The intuition relies again on the trade-off between reduction in expected product-misfit cost and the sellers' ability to increase price for consumers with improved fit.

6. Alternative Timeline

Until now, we had made the assumption that prices are easier to change than the product-fit disclosure decisions, which can involve longer term time and infrastructure investments. Under that assumption, one key takeaway was that while a manufacturer benefits from product fit disclosure for sufficiently low-quality products, the retailer(s) benefit from disclosure for both sufficiently low-quality and sufficiently high-quality products, and no channel member benefits from fit disclosure of "intermediate"-quality products. That is, if all channel members could disclose fit information, then there would be a channel conflict for sufficiently high-quality products for which the retailer(s) would disclose fit information against the wishes of the manufacturer.

One may then wonder if the manufacturer can overcome this adversarial disclosure decision for sufficiently high-quality products by its retailer(s) by committing to a suitable wholesale price in advance of retailer's disclosure decision. Intuitively, since the retailer(s) choose disclosure to improve the retail margin, the manufacturer has the following trade-off:

(i) it can commit to a wholesale price low enough to increase retailer margin enough that the retailer(s) would no longer want to disclose against the disclosure preference of the manufacturer for high-quality products;
(ii) holding constant the retailer's disclosure decision, the manufacturer may lose from this reduction in its wholesale price.

We study this trade-off for both the monopolistic and competing retailer's cases in this Section. The alternative timeline assumption would fit those real-world scenarios in which retailer disclosure decisions are easy to change after the manufacturer makes her pricing decisions. For example, retailers can try to emphasize or de-emphasize match-related product information.

Monopolistic Retailer Case. Consider the alternative timeline in which the manufacturer sets the wholesale price, a monopolistic retailer chooses whether to enable consumers to learn the product type, and then the retailer chooses the final retail price of the product. We solve this game through backward induction. First, we derive the retailer's optimal prices under both disclosure and nondisclosure using the demand scenarios shown in Figure 3.

Under disclosure, the retailer's optimal price, demand, and profits are $\frac{v+2w}{3}$, $\frac{4(v-w)^2}{9t}$, and $\frac{4(v-w)^3}{27t}$ if the two stores are local monopolies (demand scenarios 1 and 2 in Figure 3), which holds when $v - w \le \frac{3t}{4}$. The retailer's optimal price, demand, and profit are $\frac{v+w}{2} - \frac{t}{8}$, $\frac{v+w}{2} - \frac{t}{8}$, and $(\frac{v-w}{2} - \frac{t}{8})^2$ in the demand scenarios 3 and 4 in Figure 3, and the demand would fall in these scenarios under the above optimal price when $\frac{3t}{4} \le v - w \le 2 - \frac{t}{4}$. Finally, when it is demand scenario 5 in Figure 3, the retailer's optimal price, demand, and profit are $\frac{1}{6}(M - 2t + 4v + 2w - 4)$, $1 - \frac{1}{36t}(2 + t - 2v + 2w + M)^2$, and $(\frac{1}{6}(M - 2t + 4v + 2w - 4) - w)(1 - \frac{1}{36t}(2 + t - 2v + 2w + M)^2)$, where $M = \sqrt{t^2 + 4t(-v + w + 4) + 4(-v + w + 1)^2}$ and demand falls into this scenario when $v - w \ge 2 - \frac{t}{4}$.

Under nondisclosure, the retailer's optimal price, demand, and profit are $\frac{2(v+w)-1}{4}$, $\frac{2(v-w)-1}{2t}$, and $\frac{(2(v-w)-1)^2}{8t}$ under incomplete market coverage (demand scenario 2 in Figure 2), and demand would fall into this scenario when $\frac{1}{2} < v - w < t + \frac{1}{2}$. Under complete market coverage (demand scenario 3 in Figure 2), the retailer's optimal price, demand, and profit are $v - \frac{1}{2} - \frac{t}{2}$, 1, and $v - w - \frac{1}{2} - \frac{t}{2}$, which hold for $v - w \ge t + \frac{1}{2}$.

Comparing the above-derived retailer's profits from disclosure and nondisclosure, we find that the retailer will choose disclosure if

$$v-w<\begin{cases}2-\sqrt{2-t}+\frac{t}{4} & \text{if } t\leq\frac{2}{9},\\ \frac{1}{2}+\frac{\sqrt{2t}}{4}+\frac{t}{4} & \text{if } \frac{2}{9}<t\leq 1.\end{cases}\qquad (3)$$

In other words, the retailer would choose disclosure if the manufacturer leaves a small scope for retailer margin, $v-w$.

The manufacturer takes into consideration this decision rule of the retailer, and chooses its price w to maximize its profit. This yields the following optimal manufacturer price:

(i) For $0<t\leq\frac{2}{9}$,

$$w_m^*=\begin{cases}\frac{v}{3} & \text{if } v\leq\frac{9t}{8};\\ v-\frac{3t}{4} & \text{if } \frac{9t}{8}<v\leq\frac{5t}{4};\\ \frac{v}{2}-\frac{t}{8} & \text{if } \frac{5t}{4}<v\leq 4-2\sqrt{2-t}+\frac{t}{4};\\ v-2+\sqrt{2-t}-\frac{t}{4} & \text{if } v>4-2\sqrt{2-t}+\frac{t}{4};\end{cases}\qquad (4)$$

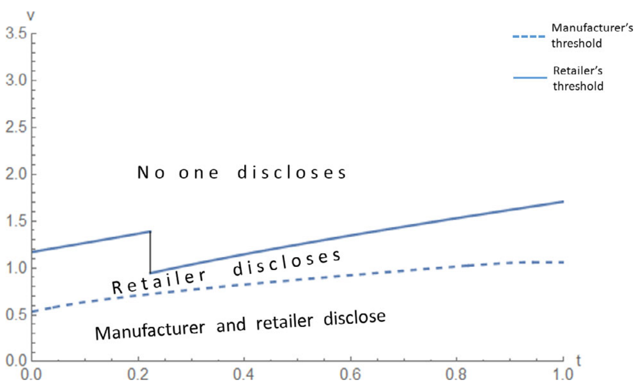
(ii) For $\frac{2}{9}<t\leq 1$,

$$w_m^*=\begin{cases}\frac{v}{3} & \text{if } v\leq\frac{9t}{8},\\ v-\frac{3t}{4} & \text{if } \frac{9t}{8}<v\leq\frac{5t}{4},\\ \frac{v}{2}-\frac{t}{8} & \text{if } \frac{5t}{4}<v\leq\frac{1}{2}(1+\sqrt{2t}+t),\\ \frac{v}{2}-\frac{1}{4} & \text{if } \frac{1}{2}(1+\sqrt{2t}+t)<v\leq\frac{1}{2}+2t,\\ v-t-\frac{1}{2} & \text{if } v>\frac{1}{2}+2t\end{cases}\qquad (5)$$

Using Equations (3), (4), and (5), we find that, in equilibrium, the retailer chooses disclosure if product quality

$$v<v_A^{MR}(t)=\begin{cases}2\left(2-\sqrt{2-t}+\frac{t}{8}\right) & \text{if } t\leq\frac{2}{9},\\ \frac{1}{2}(1+\sqrt{2t}+t) & \text{if } \frac{2}{9}<t\leq 1.\end{cases}\qquad (6)$$

Figure 7 Channel Disclosure with a Monopolistic Retailer when Manufacturer Commits to a Wholesale Price Before Disclosure Decisions [Color figure can be viewed at wileyonlinelibrary.com]



From equation (1) in section 4, we know that if the retailer did not have disclosure abilities, the manufacturer would disclose fit information if $v<v^{MR}(t)$. Noting that $v^{MR}(t)<v_A^{MR}(t)$ derived above, we reach the following conclusion:

Proposition 8. *If a manufacturer is able to commit to a wholesale price before the monopolistic retailer chooses whether to enable consumers to learn product fit information, then* (*i*) *the retailer and manufacturer share the incentive to disclose fit information for products of sufficiently low quality* ($v<v^{MR}(t)$); (*ii*) *only the retailer has the incentive to disclose fit information for products of intermediate quality* ($v^{MR}(t)\leq v\leq v_A^{MR}(t)$), *and* (*iii*) *neither the manufacturer nor the retailer discloses fit information for products of sufficiently high quality* ($v>v_A^{MR}(t)$).

Thus, for products of sufficiently high quality ($v>v_A^{MR}(t)$), the manufacturer finds it optimal to commit to a low enough wholesale price such that the scope for retail margin is high and the retailer would not find it optimal to disclose the fit information. Comparing Figures 5 and 7, we can see that if the manufacturer has the capability to commit to a wholesale price before the retailer makes its disclosure decision, the manufacturer can use it to align the retailer's disclosure incentives with her own disclosure incentives, and induce the retailer not to disclose fit information for products of sufficiently high quality.

For products that are of intermediate quality ($v^{MR}(t)\leq v\leq v_A^{MR}(t)$), the manufacturer does not find it optimal to reduce wholesale price to align the retailer's disclosure incentives with her own. She chooses to live with the retailer disclosing fit information when, left on her own, the manufacturer would not have chosen disclosure. Figure 7 shows this result graphically.

We calculate the consumer and social welfare effects of a mandatory disclosure policy in the Appendix. Proposition 8 shows that such a policy would have an effect on welfare only for products of sufficiently high quality since the channel does not disclose on its own for products of those types. We again find that such a mandatory disclosure policy can either increase or decrease consumer and social surplus.

Competing Retailers Case. We continue to use the alternative timeline in which the manufacturer first sets the wholesale price, retailers then make the disclosure decisions, and finally, retailers set the retail prices. We solve this game through backward induction.

Comparing retailers' profits under disclosure and nondisclosure in the Appendix, we find that the retailers would choose disclosure if the term $v-w$ is either sufficiently low or sufficiently high, that is, if

$$v - w \begin{cases} < d^*(t), \text{or} \\ > 1 + \frac{3t}{2}, \end{cases} \quad (7)$$

where the long expression of $d^*(t)$ is presented in the Appendix. In other words, the retailers would choose disclosure if the manufacturer leaves either sufficiently low or sufficiently high scope for the retail margin. When quality is very high, competing retailers cover the whole market. Although nondisclosure may allow them to obtain a higher total margin, the manufacturer extracts most of the gain given the strong retail competition, leaving the retailers worse off than under disclosure.

The manufacturer takes into consideration the decision rule of the retailers, and chooses the wholesale price w to maximize its profit. This yields the following optimal wholesale price:

$$w^* = \begin{cases} \frac{v}{3} & \text{if } v \leq \frac{9t}{8}; \\ v - \frac{3t}{4} & \text{if } \frac{9t}{8} < v \leq \frac{19t}{6}; \\ w_1 & \text{if } \frac{19t}{6} < v \leq 2d^*(t) - \frac{1}{2}; \\ \frac{v}{2} - \frac{1}{4} & \text{if } 2d^*(t) - \frac{1}{2} < v \leq 2t + \frac{1}{2}; \\ v - t - \frac{1}{2} & \text{if } v > 2t + \frac{1}{2}. \end{cases} \quad (8)$$

Using (6) and (7), we find that, in equilibrium, the retailers choose disclosure if

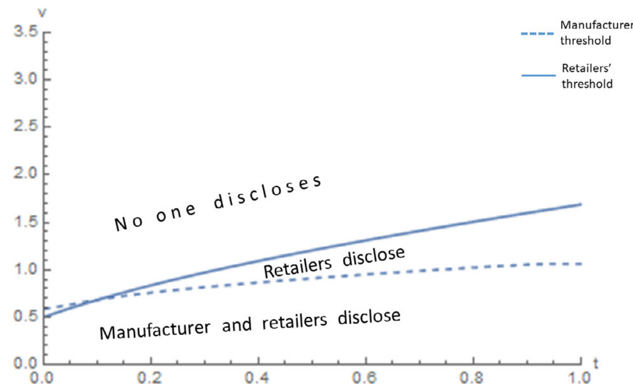
$$v < v_A^{CR}(t) = 2d^*(t) - \frac{1}{2}. \quad (9)$$

From section 5, we know that if the retailers did not have disclosure abilities, the manufacturer would choose disclosure if $v < v^{CR}(t)$. Noting that $v^{CR}(t) \lesseqgtr v_A^{CR}(t)$ for $t \gtreqless 0.1$, we reach the following conclusion, also shown in Figure 8:

Proposition 9. *If a manufacturer is able to commit to a wholesale price before competing retailers decide whether to enable the disclosure of product fit information to consumers, then* (*i*) *the retailers and manufacturer share the incentive to disclose fit information for products of sufficiently low quality* ($v < \min\{v^{CR}(t), v_A^{CR}(t)\}$); (*ii*) *only the retailers* (*manufacturer*) *have the incentive to disclose fit information for products of intermediate quality for* $t \in (0.1,1]$ ($t < 0.1$) *and* (*iii*) *neither the manufacturer nor the retailers disclose fit information for products of sufficiently high quality* ($v \geq \max\{v^{CR}(t), v_A^{CR}(t)\}$).

Comparing Figures 6 and 8, we can see that as before, the manufacturer is able to use its ability to commit to a low wholesale price to align the retailers' disclosure incentives to her

Figure 8 **Channel Disclosure with Competing Retailers when Manufacturer Commits to Wholesale Prices Before Disclosure Decisions [Color figure can be viewed at wileyonlinelibrary.com]**



own disclosure incentives, and make the retailers not disclose fit information for products of sufficiently high quality. For products of intermediate product quality, the disclosure alignment is not worth its margin loss for the manufacturer, and she lets the retailers choose disclosure in cases where the manufacturer would not have on her own.

We also show in the Appendix that a mandatory product-fit disclosure policy can, as in earlier cases, either increase or decrease consumer and social surplus.

Summary of Effects of Change in Timeline. We can summarize the product fit disclosure conflicts and outcomes in a channel under the two possible time lines as follows. Whether wholesale price is easier or harder to change than disclosure decisions, all channel members are aligned in choosing to disclose fit information for products of sufficiently low quality. For products of intermediate and sufficiently high quality, the time line affects the nature of channel conflict and equilibrium disclosure outcomes. In situations in which wholesale prices can be changed faster than disclosure decisions (Sections 4 and 5), the retailers would disclose fit information for sufficiently high-quality products against the wishes of the manufacturer, but no channel member would disclose the fit information for products of intermediate quality. On the other hand, in situations in which disclosure decisions can be changed faster than wholesale price (section 6), the retailers would disclose the fit for intermediate quality products against the wishes of the manufacturer, but no channel member would disclose the fit information for products of sufficiently high quality.

7. Summary, Limitations, and Future Research

Advances in information technology and the Internet have made it cheaper and easier for firms to disseminate product-fit information to consumers. This study explores the incentives of an upstream manufacturer and downstream retailers to provide such information to consumers to reduce their product-fit uncertainty. Our analysis shows how the disclosure of this information depends on (i) whether the manufacturer sells directly to consumers or distributes her products through retailers, (ii) the intensity of downstream retail competition, (iii) which channel members are in charge of the disclosure decision; and (iv) whether the product-fit disclosure decisions have to be made before or after the manufacturer sets her wholesale price. We also showed how mandatory disclosure policy can either increase or decrease consumers and social welfare.

Limitations and Discussion of Assumptions. From a purely modeling perspective, our model turns out to be quite challenging, limiting somewhat our ability to further extend the framework and to get more succinct equilibrium expressions. The reason is as follows. Typical models of horizontal differentiation consider one dimension of consumer heterogeneity, and further assume full market coverage to simplify the analysis and focus on competitive aspects. In our case, given the substantive nature of the problem, we examine in this study, we explicitly model two dimensions of horizontal differentiation—preference for product feature and preference for retailer. Furthermore, to fully characterize the equilibria, we *endogenize* scope of market coverage—partial coverage or full coverage—on *both* dimensions. The net result, as one can see from various demand scenarios in Figures 2 and 3, is that the expressions of consumer demand become complicated. The complicated consumer demand structure, when put in a distribution channel framework with competing retailers and channel members making information disclosure decisions, many a times yields complicated equilibrium expressions and comparisons. That being said, all our results are still analytical in nature, and we fully characterize the solution.

We have abstracted away from manufacturer competition due to the complexity of the existing model. Given that we already have two dimensions of differentiation, it is hard to add another layer of differentiation for the manufacturers. Having said that, we have analyzed what would happen if two manufacturers sell directly to consumers, each owning one of the two stores in our current model. We find that the sellers would choose disclosure for both very low and very high levels of quality, and nondisclosure for the remaining intermediate levels of quality, which is a sign that manufacturer competition would indeed have interesting implications for disclosure decisions.

We use a linear mismatch costs along both dimensions to be able 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.[12] Also, we fixed the locations of the stores at the two ends of the Hotelling line to sidestep discontinuous demand functions that tend to emerge when firms are close to each other (d'Aspremont et al. 1979, Tirole 1988).

Finally, we assume a linear pricing contract between the manufacturer and its retailers to be able to examine the economic consequences of product-fit disclosure decisions on channel members' demand and margin trade-offs. Use of a nonlinear pricing scheme, such as two-part pricing, could eliminate these trade-offs and change our results. One can justify the use of linear pricing as approximating the situations where, for unmodeled reasons such as uncertainty, asymmetric information, incomplete specificability of the product, the manufacturer cannot extract all the surplus from downstream retailers (e.g., Iyer and Villas-Boas 2003, Katz 1989, Kaufmann and Lafontaine 1994, Villas-Boas 1998).

Future Research. 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 manufacturer can then customize the disclosure decision based on such information. Intuitively, targeted disclosure can be very interesting and it may be profit enhancing in the following way. Consumers located near the mid-point between the two product locations may remain uninformed whereas consumers close to the product's actual location become informed. If the seller adopts this strategy, then the consumers who are located close to the opposite product location would correctly infer that the product is far away when they do not receive information. If demand under complete disclosure is high (e.g.,, demand scenario 5 in Figure 3), such a partial disclosure strategy can lower the expected product mismatch cost for consumers who are located near the mid-point on the opposite end to .5. These consumers would purchase the product in the full-disclosure scenario, and the reduction of expected product mismatch would create an opportunity for the seller to charge a higher level of price. As a result, the firm may be able to obtain a higher level of profit than under complete disclosure. A full characterization of the partial equilibrium would entail computing the boundary of the nondisclosure region near the mid-point, which is likely to vary with the quality of the product. This extension is intractable in our current model given our focus on and need to incorporate retail competition, but can be a valuable and interesting exercise for a simpler model that incorporates only one dimension of heterogeneity in consumer preferences.

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.

Finally, we have focused our study on costless pre-purchase disclosure that does not generate value by itself. In other words, we focus on information. When the manufacturer 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 manufacturer's disclosure threshold. Similarly, when disclosure is implemented by the retailers, disclosure costs may enlarge the intermediate quality range for nondisclosure. When the disclosure generates utility directly, for example, in the context of a software trial or a food sample, disclosure is more likely to be appealing to the channel members, unless it is accompanied by large direct costs.

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Appendix A

Section 3. The possible retail demands under nondisclosure are given in section 4. For $v < \frac{1}{2}$, demand is zero and hence the manufacturer's profit is zero. For $\frac{1}{2} \leq v < 2t + \frac{1}{2}$, the retail demand is $\frac{1}{t}(2(v - p - \frac{1}{2}))$. The manufacturer's profit maximization problem is $\max_p p \cdot \frac{1}{t}(2(v - p - \frac{1}{2}))$, which leads to profit of $\frac{(2v-1)^2}{8t}$. If $v \geq t + \frac{1}{2}$, the manufacturer charges $v - \frac{1}{2} - \frac{t}{2}$, retail demand is 1, and his profit is $v - \frac{1}{2} - \frac{t}{2}$.

The possible retail demands, $d(p;v,t)$, under disclosure are given in section 4. Manufacturer's profit maximization problem is $\max_p p \cdot d(p; v, t)$. Solving these, we get the manufacturer's maximal profit as (i) $\frac{4v^3}{27t}$ for $0 < v < \frac{3t}{4}$, (ii) $\frac{(4v-t)^2}{64}$ for $\frac{3t}{4} \leq v < \frac{8-t}{4}$, and (iii) $\frac{(4+2t-4v-Z_1)[t^2+t(Z_1-4v-8)-2(v-1)(Z_1+2-2v)]}{108t}$ for $v \geq \frac{8-t}{4}$, where $Z_1 = \sqrt{t^2 + 4(v-1)^2 - 4t(v-4)}$.

Comparison of these profits under disclosure and nondisclosure yields the benchmark results in section 3.

Section 4. In sections 4.1 and 4.2, wholesale price is w_1, retail margin is m_1, retail price is $w_1 + m_1$, consumer demand is D_1, manufacturer's profit is $\pi_D^M = w_1 D_1$, and retailer's profit is $\pi_R^M = m_1 D_1$, where the expressions of w_1, m_1, and D_1 are given below (notation: the nth exact root of polynomial $f(x;a) = 0$ is obtained as Root[$f(x;a)$,n] in Mathematica),

$$D_1 = -\frac{1}{18t}[t^2 + t(\sqrt{t^2+4t(-v+w_1+4)+4(-v+w_1+1)^2} -4v+4w_1-8) - 2(v-w_1-1)(\sqrt{t^2+4t(-v+w_1+4)+4(-v+w_1+1)^2} -2v+2w_1+2)],$$

$$m_1 = \frac{1}{6}(\sqrt{t^2+4t(-v+w_1+4)+4(-v+w_1+1)^2} - 2t + 4v - 4w_1 - 4),$$

$$w_1 = \mathrm{Root}[K_1(w; v, t), 2],$$

$$\begin{aligned} K_1(w; v, t) = {} & 48w^4 + w^3(80t - 160v + 160) + w^2 \\ & (48t^2 - 192tv + 336t + 192v^2 - 384v + 192) \\ & + w(12t^3 - 72t^2v + 152t^2 + 144tv^2 - 448tv \\ & + 304t - 96v^3 + 288v^2 - 288v + 96) \\ & + t^4 - 8t^3v + 16t^3 + 24t^2v^2 - 80t^2v + 8t^2 \\ & - 32tv^3 + 128tv^2 - 160tv + 64t + 16v^4 \\ & - 64v^3 + 96v^2 - 64v + 16. \end{aligned}$$

Section 5. In sections 5.1 and 5.2, wholesale prices are w_2 and w_3, retail margins are m_2 and m_3, retail prices are $w_2 + m_2$ and $w_3 + m_3$, consumer demands are D_2 and D_3, manufacturer's profits are $Z_2 = 2w_2D_2$ and $Z_3 = 2w_3D_3$, and each retailer's profits are $Z_4 = m_2D_2$ and $Z_5 = m_3D_3$ where

$$D_2 = \frac{1}{8}\left(\sqrt{13t^2 + 4t(w_2 - v) + 4(v - w_2)^2} - 4t + 2v - 2w_2\right),$$
$$w_2 = \mathrm{Root}[K_2(w; v, t), 1],$$
$$m_2 = \frac{1}{4}\left(-\sqrt{13t^2 + 4t(w_2 - v) + 4(v - w_2)^2} + 3t + 2v - 2w_2\right),$$
$$D_3 = \frac{2t - \frac{1}{32}\left(\sqrt{t^2 + 4t(-v + w_3 + 12) + 4(v^2 - 2v(w_3 + 4) + w_3(w_3 + 8) + 8)} + t - 2v + 2w_3\right)^2}{4t},$$
$$w_3 = \mathrm{Root}[K_3(w; v, t), 2] \text{ for } t \le 0.696693, \text{ or } 0.696693 < t \le 1 \quad \text{and} \quad v > v_1 > \frac{-t^3 + t^2 + 19t + 8}{t^2 + 4t + 4},$$
$$= \mathrm{Root}[K_3(w; v, t), 4] \text{ for } 0.696693 < t \le 1 \quad \text{and} \quad \frac{-t^3 + t^2 + 19t + 8}{t^2 + 4t + 4} \le v < v_1,$$
$$m_3 = \frac{1}{8}\left(\sqrt{t^2 + 4t(-v + w_3 + 12) + 4(v^2 - 2v(w_3 + 4) + w_3(w_3 + 8) + 8)} - 3t + 6v - 6w_3 - 8\right),$$

where

$$K_2(w; v, t) = 32w^3 + w^2(52t - 80v) + w(108t^2 - 56tv + 64v^2) + 13t^3 - 56t^2v + 20tv^2 - 16v^3,$$
$$K_3(w; v, t) = 48w^4 + w^3(80t - 160v + 512) + w^2(48t^2 - 192tv + 992t + 192v^2 - 1120v + 976) + w(12t^3 - 72t^2v + 432t^2 + 144tv^2 - 1248tv + 1040t - 96v^3 + 768v^2 - 1312v + 640) + 128 + 192t + 36t^2 + 48t^3 + t^4 - 384v - 528tv - 232t^2v - 8t^3v + 400v^2 + 352tv^2 + 24t^2v^2 - 160v^3 - 32tv^3 + 16v^4,$$
$$v_1 = \mathrm{Root}[K_4(v; t), 1],$$
$$K_4(v; t) = 128v^5 + v^4(432t^2 - 608t - 2192) + v^3(-864t^3 - 5152t^2 + 11872t + 12896) + v^2(648t^4 + 19280t^3 + 2616t^2 - 76800t - 27824) + v(-216t^5 - 15152t^4 - 107192t^3 + 154680t^2 + 143024t + 25088) + 27t^6 + 3434t^5 + 156139t^4 - 90856t^3 - 193004t^2 - 80512t - 8096.$$

Expression of $v^{CR}(t)$. Comparing the seller's profit from nondisclosure and disclosure shown in the paper, we get $v^{CR}(t) =$ (i) $\mathrm{Root}[K_5(v; t), 1]$, for $0 \le t < 0.083$; (ii) $\mathrm{Root}[K_6(v; t), 2]$, for $0.083 \le t < 0.605$; (iii) $\mathrm{Root}[K_6(v; t), 4]$, for $0.605 \le t < 0.884$; (iv) $\frac{1}{2}(t^2 + \sqrt{(t-2)(t-1)t^2} + 1)$ for $0.884 \le t < 0.943$; and (v) 1.06 for $0.943 \le t < 1$, where

$$K_5(v; t) = v^4(576t^2 + 1536t + 1024) + v^3(-864t^3 - 9984t^2 - 11520t - 5120) + v^2(2196t^4 + 17760t^3 + 36544t^2 + 22016t + 6400) + v(-972t^5 - 27600t^4 - 41136t^3 - 34880t^2 - 14464t - 3072) + 117t^6 + 18288t^5 + 23032t^4 + 17984t^3 + 9616t^2 + 3072t + 512,$$
$$K_6(v; t) = v^6(256t - 256) + v^5(1536t^3 - 2176t^2 - 512t + 768) + v^4(2304t^5 - 8448t^4 + 1936t^3 + 4352t^2 + 384t - 960) + v^3(-3456t^6 + 9312t^5 + 8448t^4 - 6560t^3 - 3264t^2 - 128t + 640) + v^2(8784t^7 - 18288t^6 - 9312t^5 - 2112t^4 + 5208t^3 + 1088t^2 + 16t - 240) + v(-3888t^8 + 18288t^6 + 2328t^5 - 1736t^3 - 136t^2 + 48) + 468t^9 - 4572t^6 + 217t^3 - 4.$$

Expression of $v_L^{CR}(t)$. Comparing the retailer's profit from nondisclosure and disclosure shown in the paper, we get $v_L^{CR}(t) = \mathrm{Root}[K_7(v; t), 2]$, where

$$K_7(v; t) = 64v^6 + v^5(-256t^2 - 192) + v^4(2240t^3 + 512t^2 + 240) + v^3(-3840t^5 - 4480t^3 - 384t^2 - 160) + v^2(-9216t^7 + 19776t^6 + 3840t^5 + 3360t^3 + 128t^2 + 60) + v(4608t^8 - 19776t^6 - 960t^5 - 1120t^3 - 16t^2 - 12) - 576t^9 + 4944t^6 + 140t^3 + 1.$$

Expression of $v_H^{CR}(t)$. Comparing the retailer's profit from nondisclosure and disclosure shown in the paper, we get $v_H^{CR}(t) =$ (i) $\frac{1}{36t}(9t^2 - 30t + 2(21t + 4)\sqrt{6t+1} - 8)$ for $0 \le t < 0.708$; (ii) $\text{Root}[K_8(v;t), 4]$ for $0.708 \le t < 0.829$; and (iii) $\text{Root}[K_8(v;t), 3]$ for $0.829 \le t < 1$, where

$$K_8(v;t) = v^4(64t^2 - 128t + 64) + v^3(-8t^4 - 256t^3 + 176t^2 + 352t - 256) + v^2(12t^5 + 336t^4 + 304t^3 - 640t^2 - 448t + 384) + v(-6t^6 - 140t^5 + 876t^4 - 2064t^3 + 1284t^2 + 352t - 256) + 64 - 128t - 882t^2 + 1028t^3 + 2674t^4 - 2526t^5 - 94t^6 + t^7.$$

Section 6, Competing retailers' reaction functions under the alternative timeline.

Using the nondisclosure demand scenarios shown in Figure 2, each retailer's optimal price and profit under nondisclosure are:

(i) $\frac{1}{4}(2v + 2w - 1)$ and $\frac{(-2v+2w+1)^2}{16t}$ when $\frac{1}{2} < v - w < t + \frac{1}{2}$;
(ii) $v - \frac{1}{2} - \frac{t}{2}$ and $\frac{1}{2}((v - w) - \frac{1}{2} - \frac{t}{2})$ when $t + \frac{1}{2} < v - w < \frac{1}{2}(3t + 1)$;
(iii) $t + w$ and $\frac{t}{2}$ when $v - w > \frac{1}{2}(3t + 1)$.

Similarly, using the disclosure demand scenarios shown in Figure 3, each retailer's optimal price and profit under disclosure are:

(i) $\frac{v+2w}{3}$ and $\frac{2(v-w)^3}{27t}$ when $v - w \le \frac{3t}{4}$;
(ii) $\frac{1}{4}(-N_1 + 3t + 2(v + w))$ and $\frac{1}{32}t(7N_1 - 25t + 2v - 2w)$ when $\frac{3t}{4} < v - w < \frac{-t^2+6t+4}{2(t+2)}$;
(iii) $\frac{1}{8}(-8 - 3t + 6v + 2w + N_2)$ and

$$\frac{(-N_2 + 3t - 6v + 6w + 8)(t(N_2 - 4v + 4w - 8) - 2(v - w)(N_2 - 2v + 2w) + t^2 + 16(-v + w + 1))}{512t}$$

when $\frac{-t^2+6t+4}{2(t+2)} \le v - w < \frac{3t}{2} + 1$;
(iv) $-\frac{t}{2} + v - 1$ and $\frac{1}{4}(-t + 2v - 2w - 2)$ when $v - w \ge 1 + \frac{3t}{2}$

where $N_1 = \sqrt{13t^2 + 4t(w - v) + 4(v - w)^2}$, and

$$N_2 = \sqrt{t^2 + 4t(-v + w + 12) + 4(v^2 - 2v(w + 4) + w(w + 8) + 8)}.$$

Comparing the above-derived profits from disclosure and nondisclosure, we find that retailers will choose to disclose if $v - w > 1 + \frac{3t}{2}$, or $v - w < d^*(t) = \text{Root}[K_9(d;t), 2]$ where

$$K_9(d;t) = 16d^4 + d^3(-8t^2 - 32) + d^2(-48t^4 + 100t^3 + 8t^2 + 24) + d(24t^5 - 100t^3 - 2t^2 - 8) - 3t^6 + 25t^3 + 1.$$

Effect of Mandatory Disclosure on Consumer Surplus and Social Welfare.

Consumer surplus under nondisclosure is $\int\int(v - \frac{1}{2} - tx - p_{ND})dxdy$, where p_{ND} is the nondisclosure price and the integration is over the x- and y-axis that is covered under the given market structure and the given values of v and t. Recalling that we have assumed, without loss of generality, the location of the product to be at $y = 0$, consumer surplus under disclosure is $\int\int(v - y - tx - p_D)dxdy$, where p_D is the disclosure price, and the integration is over the x- and y-axis that is covered under the given market structure and the given values of v and t. Social welfare adds all firms' profits to the total consumer surplus in a given situation. It is then easy to calculate consumer surplus and social welfare since we have already derived the price, demand, and firms' profit for all values of v and t for all examined market structures for both disclosure and nondisclosure scenarios.

(1) Channel with a Monopolist Retailer (Disclosure First, Wholesale Price Second).

From Proposition 3 and Figure 5, the relevant zone where mandatory disclosure can bind is when the product has intermediate quality. Specifically, in the following zone:

(i) for $0.0408163 \le t < 0.820194$, $\frac{1}{4}(t + \sqrt{2}\sqrt{t} + 2) < v < \frac{1}{4}(t + 8\sqrt{2}\sqrt{t})$, and
(ii) for $0.820194 \le t < 1$, $0.707107t^{3/2} + 0.5 < v < \frac{1}{4}(t + 8\sqrt{2}\sqrt{t})$.

Then calculating and comparing consumer surplus under disclosure and nondisclosure in this zone, we get that consumer surplus reduces from mandatory disclosure when the value of v is intermediate within the relevant zone, that is,

$$0.204124\sqrt{\frac{t(t(3-8t)-6)}{t-2}}+0.25t+0.5<v<0.57735\sqrt{t(24-t)}+0.25t.$$

It increases otherwise.

Similarly, calculating and comparing social welfare under disclosure and nondisclosure, we get that social welfare reduces from mandatory disclosure when the value of v is intermediate within the relevant zone, that is:

$$\text{for } 0.0408196<t\leq 0.0408296,\ 0.25t+2.28571-0.0824786\sqrt{432-7t^2}<v<0.25t+2.82843\sqrt{t};$$
$$\text{for } 0.0408296<t\leq 0.86919,\ 0.0771517\sqrt{\frac{t(t(21-8t)-42)}{t-2}}+0.25t+0.5<v<0.25t+2.82843\sqrt{t};$$
$$\text{for } 0.86919<t\leq 0.991815,\ 0.285714t^2+0.116642\sqrt{t(6t-14)+21t}+0.5<v<0.25t+2.82843\sqrt{t};$$
$$\text{for } 0.991815<t<1,\ 0.707107t^{3/2}+0.5<v<0.25t+2.82843\sqrt{t}.$$

$$v_3=\left[\frac{t((0.354592t-2.96939)t+0.918367)}{(0.857143-t)^2}+0.0721688\sqrt{\frac{t(t(t(t(2049.28-80.267t)-3048.53)+2432.59)-975.913)+207.274)}{(0.857143-t)^4}}\right],$$

Social welfare increases otherwise.

(2) Channel with a Monopolist Retailer (Wholesale Price First, Disclosure Second).

From Proposition 8 and Figure 7, the relevant zone where mandatory disclosure can bind is when products have sufficiently high quality. Specifically, in the following zone:

(i) for $0<t\leq \frac{2}{9}$, $v>2(2-\sqrt{2-t}+\frac{t}{8})$, and
(ii) for $\frac{2}{9}<t<1$, $v>\frac{1}{2}(1+\sqrt{2t}+t)$.

Then calculating and comparing consumer surplus under disclosure and nondisclosure in this zone, we get that consumer surplus reduces from mandatory disclosure when the value of v is low within the relevant zone, that is,

$$\text{for } \frac{2}{9}<t<1,\quad v<\frac{1}{12}(3t+4\sqrt{3}\sqrt{(24-t)t}).$$

It increases otherwise.

Similarly calculating and comparing social welfare under disclosure and nondisclosure, we get that social welfare reduces from mandatory disclosure everywhere except for some intermediate values of v within the relevant zone, that is,

$$\text{for } 0<t<0.576045,\quad \frac{1}{4}(16-3t)<v<\frac{t^2+12}{6t}.$$

(3) Channel with Competing Retailers (Disclosure First, Wholesale Price Second).

Calculating and comparing consumer surplus under disclosure and nondisclosure in the relevant zone from Proposition 7 and Figure 6, we get that consumer surplus reduces from mandatory disclosure when the value of v is intermediate within the relevant zone, that is, (i) for $0.287411<t\leq 0.480026$, $v_2<v<v_3$; (ii) for $0.480026<t\leq 0.5$, $v_4<v<v_3$; (iv) for $0.5<t\leq 0.637208$, $v_5<v<v_3$, where $v_2=\text{Root}[K_{10}(v;t),2]$, $v_4=\text{Root}[K_{10}(v;t),4]$, $v_5=\text{Root}[K_{10}(v;t),3]$,

$$K_{10}(v;t)=v^6(6912t-3456)+v^5(-17280t^2-13824t+10368)+v^4(-64512t^4+43632t^3+34560t^2+10368t-12960)+v^3(223488t^5+64512t^4-87264t^3-25920t^2-3456t+8640)+v^2(150528t^7-445824t^6-223488t^5-16128t^4+65448t^3+8640t^2+432t-3240)+v(-106752t^8+445824t^6+55872t^5-21816t^3-1080t^2+648)+81856t^9-111456t^6+2727t^3-54.$$

Consumer surplus increases otherwise.

Similarly, calculating and comparing social welfare under disclosure and nondisclosure, we get that social welfare reduces from mandatory disclosure everywhere except for some intermediate values of v within the relevant zone, that is, (i) for $0 < t \le 0.0778335$, $v_6 < v < v_7$; (ii) for $0.1079 < t \le 0.33334$, $v_8 < v < v_9$; and (iii) for $0.33334 < t \le 0.541599$, $v_{10} < v < v_9$, where $v_6 = \text{Root}[K_{11}(v;t),1]$, $v_7 = \text{Root}[K_{12}(v;t),1]$, $v_8 = \text{Root}[K_{13}(v;t),2]$, $v_9 = \text{Root}[K_{14}(v;t),2]$, $v_{10} = \text{Root}[K_{15}(v;t),2]$,

$$\begin{aligned}K_{11}(v;t) &= v^4(576t^2+1536t+1024)+v^3(-864t^3\\&-9984t^2-11520t-5120)+v^2(2196t^4\\&+17760t^3+36544t^2+22016t+6400)\\&+v(-972t^5-27600t^4-41136t^3-34880t^2\\&-14464t-3072)+117t^6+18288t^5+23032t^4\\&+17984t^3+9616t^2+3072t+512,\end{aligned}$$

$$\begin{aligned}K_{12}(v;t) &= v^4(46656t^2+124416t+82944)+v^3(2592t^3\\&-286848t^2-532224t-304128)+v^2(468t^4\\&-67104t^3+304128t^2+615168t+352512)\\&+v(-1140t^5-12600t^4+60336t^3-105408t^2\\&-273024t-165888)+1009t^6+11340t^5\\&+19980t^4-7344t^3+9936t^2+41472t+27648,\end{aligned}$$

$$\begin{aligned}K_{13}(v;t) &= v^6(256t-256)+v^5(1536t^3-2176t^2-512t\\&+768)+v^4(2304t^5-8448t^4+1936t^3+4352t^2\\&+2304t^5-8448t^4+1936t^3+4352t^2+384t\\&-960)+v^3(-3456t^6+9312t^5+8448t^4\\&-6560t^3-3264t^2-128t+640)+v^2(8784t^7\\&-18288t^6-9312t^5-2112t^4+5208t^3+1088t^2\\&+16t-240)+v(-3888t^8+18288t^6+2328t^5\\&-1736t^3-136t^2+48)+468t^9-4572t^6\\&+217t^3-4,\end{aligned}$$

$$\begin{aligned}K_{14}(v;t) &= v^6(1.01606\times10^6t-1.18541\times10^6)+v^5\\&(3.48365\times10^6t^3-5.24966\times10^6t^2-2.03213\\&\times10^6t+3.55622\times10^6)+v^4((2.98598\times10^6t^5\\&-7.16083\times10^6t^4-)4.01285\times10^6t^3+1.04993\\&\times10^7t^2+1.5241\times10^6t-4.44528\times10^6)\\&+v^3(165888t^6-3.66912\times10^6t^5+7.16083\\&\times10^6t^4+1.92931\times10^6t^3-7.8745\times10^6t^2\\&-508032t+2.96352\times10^6)+v^2(29952t^7\\&-1.27008\times10^6t^6+3.66912\times10^6t^5-1.79021\\&\times10^6t^4-793800t^3+2.62483\times10^6t^2+63504t\\&-1.11132\times10^6)+v(-72960t^8+1.27008\times10^6t^6\\&-917280t^5+264600t^3-328104t^2+222264)\\&+64576t^9-317520t^6-33075t^3-18522,\end{aligned}$$

$$\begin{aligned}K_{15}(v,t) &= 64v^6+v^5(-256t^2-192)+v^4(2240t^3\\&+512t^2+240)+v^3(-3840t^5-4480t^3\\&-384t^2-160)+v^2(-9216t^7+19776t^6\\&+3840t^5+3360t^3+128t^2+60)\\&+v(4608t^8-19776t^6-960t^5-1120t^3\\&-16t^2-12)-576t^9+4944t^6+140t^3+1.\end{aligned}$$

(4) Channel with Competing Retailers (Wholesale Price First, Disclosure Second).

Calculating and comparing consumer surplus under disclosure and nondisclosure in the relevant zone shown in Proposition 9 and Figure 8, we get that consumer surplus reduces from mandatory disclosure when the value of v is intermediate within the relevant zone, that is, (i) for $0.287411 < t \le 0.480026$, $v_2 < v < v_3$; (ii) for $0.480026 < t \le 0.5$, $v_4 < v < v_3$; (iv) for $0.5 < t \le 0.637208$, $v_5 < v < v_3$, where v_2, v_3, v_4, and v_5 were defined earlier in the Appendix.

Similarly, calculating and comparing social welfare under disclosure and nondisclosure, we get that social welfare reduces from mandatory disclosure everywhere except for some intermediate values of v within the relevant zone, that is,

(i) for $0 < t < 0.707432$, $\frac{-3t^3+10t^2+22t+16}{2t^2+8t+8} < v < \frac{-t^3+t^2+19t+8}{t^2+4t+4}$; and
(ii) for $0.707432 < t < 1$ and $\frac{-3t^3+10t^2+22t+16}{2t^2+8t+8} < v < \frac{1}{6}t(t^2+12)$;
(iii) for $0 < t < 0.0778335$, $v_6 < v < v_7$; and
(iv) for $0.0833786 < t < 0.10123$, $v_8 < v < 0.5+2t$, where v_6, v_7, and v_8 were defined earlier in the Appendix.

Notes

[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, last accessed on November 1, 2018.
[2]See https://www.businessinsider.com/gilt-groupe-photo-shoot-2010-7?op=1, last accessed on November 1, 2018.
[3]See https://casper.com/reviews, last accessed on November 1, 2018.
[4]We use the terms "match" and " fit" interchangeably.
[5]We describe in details other related research in the next Section.
[6]For example, Sony and BestBuy/NewEgg for electronics products; Patagonia and REI/Dick's Sporting Goods for outdoor clothing and gear; Clinique and Sephora/Macy's for skincare products; Swiss Gear and Target/Walmart for travel bags; Craftsman and Lowe's/Home Depot for lawn mowers.

[7]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.

[8]An alternative interpretation of the effect of disclosure in our model is that while consumers can figure out their match values with the product, they may not know the importance of the attribute which can be influenced by the seller (e.g., Zhu and Dukes 2017). A "disclosure" strategy would highlight the importance of the attribute and hence make consumers fully assess their match values before making the purchase decision, whereas a "nondisclosure" strategy would suppress the importance of the attributes and leave consumers indifferent, deriving a general match value, 1/2, without researching the attributes carefully.

[9]Throughout the paper, we refer to the manufacturer as "she," the retailer as "it" and the consumer as "he."

[10]We thank an anonymous reviewer for suggesting this question.

[11]As in the case of monopolistic retailer, total channel profit maximization leads to a disclosure threshold close to that of the manufacturer, implying nondisclosure for products of sufficiently high quality.

[12]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. $\frac{1}{4} < v \leq \frac{5}{4}$), in which case the manufacturer's profit is $\frac{1}{16}\pi v^2$ (resp. $\frac{\pi}{8}(v - \frac{1}{4})^2$). 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 manufacturer's profit is $v - \frac{9}{4}$ (resp. $v - \frac{7}{4}$). She prefers nondisclosure.

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