Strategic Information Disclosure:  
The Case of Multi-Attribute Products with Heterogeneous Consumers*

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May 2004

Abstract

We examine the incentives for firms to voluntarily disclose otherwise private information about quality attributes of differentiated products. In particular, we focus on the case when those products have multiple attributes and consumers are heterogeneous in their tastes over these attributes. We show that there exist certain configurations of consumer multi-dimensional preferences under which firms, even with high-quality products, may not choose to reveal their types. This failure of voluntary disclosure will arise when more information results in more elastic demand and hence triggers more intense price competition, leading to lower prices and profits for all firms. The escalation of competition can make all firms worse off and not to disclose the quality of their products, even with zero disclosure costs. As a result, the equilibrium in which disclosure is voluntary may diverge from that in which disclosure is mandatory.

JEL: L15 (Information and Product Quality); L5 (Regulation and Industrial Policy)  
Keywords: Quality Disclosure; Multiple Attributes; Consumer Heterogeneity

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1. Introduction

As technological innovation constantly expands the dimensionality of the product attribute space, the lack of information on quality has become increasingly a concern for the modern economy. However, a strand of economic literature, initiated independently by Grossman (1981) and Milgrom (1981), claims that this concern can be dismissible. They argue that firms will have full incentives to voluntarily disclose the quality of their products as long as there is a verifiable and accurate disclosure mechanism with negligible costs. In equilibrium all the private information will “unravel”, and a mandatory disclosure mechanism achieves the same effects as a voluntary one.¹

If this argument holds true, one may wonder why industry associations are constantly against the imposition of mandatory disclosing laws by the government. As far as back in 1976, the lobbying by the National Automobile Dealers Association led to the abolishment of the FTC mandatory inspection and disclosure rules on the used-car dealers. In 1998, the National Restaurant Association was strongly against the required public display of hygiene grade cards of all the restaurants in the Los Angeles County.² As recent as in 2000, the National Hospital Association opposed a proposal by President Bill Clinton requiring mandatory reporting of fatal and other serious medical errors.³ Questions arise naturally: what do these associations worry about, should the mandatory disclosure regime make no difference from the voluntary one? Besides the all the claims made about the subjective standards of quality and high costs of information acquisition, shall we suspect some lucrative motives behind the scene? Might

¹ The logic of their finding is as follows. If no firm discloses product quality, consumers will believe the highest-quality product to be no different from the lower-quality ones. As a result, firms producing products with the highest quality will disclose their quality, because they will then be able to charge higher prices and achieve higher profits. Then firms with the next highest quality products will have the same incentive to distinguish themselves from the remaining firms. This process continues, so long as the benefits of disclosure outweigh the costs. In the limit when disclosure costs are zero, the situation in which firms hold private information about product quality “unravels.”

² See Food Council News, Vol. 5, issue 1, January 2002. The National Restaurant Association states “rating initiatives reduce complex issues to a score or letter based on subjective decisions by individual inspectors.” The industry maintains that if an establishment is good enough to pass inspection, ratings are overkill.

³ See CNN news, February 22, 2000. “A culture of silence” in the medical profession can be traced back to 1930s, when physicians were advised to “keep a cautious tongue” regarding medical errors (Gallagher et al, 2002).
mandatory disclosing laws bring consumers more information than what firms would voluntarily provide? If yes, does consumers’ possession of more information harm firms’ profits?

These are the central issues this paper investigates. Following Grossman (1981), Milgrom (1981), and subsequent studies, we consider firms’ voluntary decisions to provide information about a product quality dimension unobserved by consumers. We assume that firms have access to a mechanism with which they can credibly disclose information with negligible costs. In particular, we focus on the case that products have multiple attributes which different consumers value differently. Following the literature on product differentiation and hedonic pricing, we consider a model in which products are both horizontally and vertically differentiated and where quality (the vertical attribute) is not observable by consumers. 4 We show that firms whose products are high in quality may actually benefit from maintaining consumer ignorance about their product. This situation will arise if the elasticity of demand becomes more, rather than less, elastic after disclosure. Whether demand becomes more or less elastic after disclosure in turn depends on the distribution of consumer heterogeneity over both the horizontal and vertical attributes of products. If demand becomes more elastic, disclosure will lead to intense price competition between high- and lower-quality rivals, causing prices and profits to fall for all. As such, no firm in a market would find it in its interest to voluntarily disclose the quality of their products, even though disclosure costs are zero.

This paper offers alternative explanations for the non-robustness of what has become known as the “unraveling result”, emphasizing firms’ strategic considerations under the context of product differentiation and consumer heterogeneity. As a result of the Grossman and Milgrom “unraveling” process, there is little scope for firms to act strategically with respect to product quality disclosure decisions. High-quality firms, by distinguishing themselves from lower-quality ones, can always gain from revealing their true quality level by charging a premium for the quality difference. Only those with the lowest

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4 The work of Becker (1965), Lancaster (1966), Muth (1966), Rosen (1974), and Gorman (1980) views all goods and services as bundles of characteristics. Tastes are plausibly heterogeneous over these attributes and, thus, over the bundles. These two features—products-as-bundles-of-characteristics and consumer-heterogeneity—are at the core of the literature on product differentiation and hedonic pricing.
quality will choose no revelation, but their non-disclosure is as revealing: consumers with rational expectation correctly infer that non-disclosure is always associated with the lowest quality.

A number of subsequent studies have examined the refinements of the Grossman and Milgrom models. Researchers have investigated certain types of disclosure costs (Jovanovic, 1982; Verrecchia, 1983; Dye, 1986), costs of information acquisition by sellers (Matthews and Postlewaite, 1985; Farrell, 1986; Shavell, 1994), consumers’ limited understanding of sellers’ disclosure (Fishman and Hagerty, 1999), consumers’ uncertainty of the existence of information (Dye and Sridhar 1995; Stivers, 2002), and alternative market structures (Jin, 2000). For most of these extensions, the failure to obtain voluntary disclosure from sellers hinges on some form of costs associated with disclosure.\(^5\) The basic conclusion that complete voluntary disclosure by sellers will occur in equilibrium continues to hold, so long as disclosure costs are zero. As has been noted elsewhere,\(^6\) this has rather startling implications for regulatory policy for products and services with quality attributes that are difficult for consumers to determine prior to their purchase. It would appear to imply that mandatory disclosure requirements are, at best, redundant. More precisely, this suggests that the only “intervention” needed by consumers is the government ensuring the availability of low-cost and credible disclosure mechanisms for sellers to use.

We are able to show that the “unraveling” result may fail even if there are no costs associated with disclosure. Our work brings the essence of product differentiation literature to the area of information disclosure by considering the tension between the benefits to a firm by differentiating from its competitors and those by maximizing its attractiveness to a large consumer base. While we assume that the attributes of products are exogenously given, we note that the decisions of firms about whether to disclose a quality dimension are similar to their decisions to differentiate their products along that dimension. The

\(^5\) Two exceptions: Fishman and Hagerty (1999) argue that voluntary disclosure may not occur when a subset of consumers in the market are “unsophisticated” and do not understand the information disclosed by sellers. Dye and Sridhar (1995) as well as Stivers (2002) argue that firms may want to exploit consumers’ uncertainty about the existence of the quality dimension and pool with the state that the information is not existent.

\(^6\) Fishman and Hagerty (1997) offer a survey and discuss policy implications.
failure of complete voluntary disclosure will arise if what disclosure does it to merely add vertical differentiation into a product world with existing horizontal differentiation. 7

In the literature on informative advertising 8, Grossman and Shapiro (1984) consider the strategic effect of firms’ using advertising to provide truthful information about their location. They find that firms’ profits may increase with the cost of advertising because reduced advertising increases informational product differentiation, which may allows firms to raise prices. A noteworthy observation of this nature is that some professions do not resist—and sometimes encourage—legal restrictions on advertising (Peters, 1984). This strategic effect, in principle, is similar to the one that we argue can discourage firms from voluntarily disclosing the quality of their products.

The remainder of the paper is organized as follows. In section 2, we develop and analyze a duopoly model with two attributes, heterogeneous consumers, and private information. In section 3, we provide an intuitive explanation of how disclosure can affect demand elasticity and in turn change firms’ willingness to voluntarily disclose information. In section 4 we describe the policy and potentially empirical implications of our model and offer some concluding remarks.

2. Model

2.1 Set Up

We describe the model set up in this section. We consider a duopoly model in which two firms sell products with two attributes. Each firm, Firm A or B, is endowed with a product \( Y_j \), where \( j = A, B \). These products differ across firms in their horizontal attribute, location (denoted by \( L \)) 9, and in their vertical attribute, the quality of their product (denoted by \( Q \)), so that \( Y_j = Y(L_j, Q_j) \). We assume that these

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7 Our results do not require this particular configuration of product differentiation. Products may consist of attributes with any mix of horizontally- and vertically-differentiated attributes.
8 Informative advertising refers to truthful information provision about products’ prices, attributes, etc.
9 We use location as a typical example of horizontal attributes of a product. Horizontal attributes are the ones on
attributes are exogenously given and cannot be altered. With respect to the horizontal attribute, firms are located vis-à-vis consumers at the end points of a linear city, as shown by the following diagram. Let $L_j$ ($0 \leq L_j \leq 1$) denote the location of firm $j$ in the linear city. Firm $A$’s location is fixed at $L_A = 0$ and firm $B$’s at $L_B = 1$. With respect to the vertical attribute, we assume that firm $A$ sells a low-quality product ($Q_A = q_l$), while firm $B$ sells a high-quality one ($Q_B = q_h$). We denote the difference in quality between these two products by $\Delta$ ($\Delta = q_h - q_l > 0$).

![Diagram of the Linear City](image)

**The Linear City**

Consumers are uniformly distributed along the linear city, where $X_i$ ($0 \leq X_i \leq 1$) denotes the $i^{th}$ consumer’s location, that is, consumers differ with respect to their proximity to the two firms. We denote the distance of the $i^{th}$ consumer from the $j^{th}$ product as $D_{ij} = |L_j - X_i|$. Consumers evaluate their transportation costs, product quality, and the prices of products, $P_j$, to make a purchase decision. More precisely, the $i^{th}$ consumer values any given product according to the following utility function:

$$U_i(D_{ij}, Q_j, P_j) \equiv V + \theta Q_j - \lambda D_{ij} - P_j$$  \hspace{1cm} (1)

where $V$ is the stand-alone value of consuming either good (instead of consuming neither). We normalize the utility from consuming neither is 0 and assume $V$ is high enough that no consumer will choose this outside option. We also normalize the disutility coefficient of paying price $P_j$ to 1. As specified in (1), consumers obtain the same disutility per unit of distance they must travel to purchase a particular product ($\lambda > 0$) but they differ with respect to the distances they have to travel.$^{10}$ To capture consumer

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10 The greater the value of $\lambda$ is, the harder it is for consumers to travel from one end of the city to the other. Thus $\lambda$
heterogeneity with respect to the vertical attribute in a parsimonious way, we assume that there are two
types of consumers: One type is the quality-lovers, who value quality (\( \theta_i = \theta \) and \( \theta > 0 \)); the other type
is the quality-neutrals, who value quality less (\( \theta_i = \theta_0 \) and \( \theta_0 < \theta \)). We set \( \theta_0 = 0 \) as normalization. It
follows that \( \theta \) measures the spread of consumer heterogeneity over the vertical attribute
(\( \theta - \theta_0 = \theta - 0 = \theta \)).

A crucial dimension of consumer heterogeneity concerns the joint distribution of their location
and tastes for product quality. At the extreme, consumers’ location and their tastes for quality may be un-
correlated, i.e., \( \Pr(X_i, \theta_i) = \Pr(X_i) \times \Pr(\theta_i) \). This is but one possible distribution. The distribution of
consumer location and tastes for quality, in fact, may be correlated. To allow for this possibility in a trac-
table way, we assume consumers’ location and quality preferences are distributed according to the following conditional probability functions:

\[
\Pr(\theta_i = \theta | X_i) = \beta X_i + \frac{1-\beta}{2} \tag{2}
\]

\[
\Pr(\theta_i = 0 | X_i) = -\beta X_i + \frac{1+\beta}{2} \tag{3}
\]

where \( \beta \in [-1,1] \). The degree of correlation in consumer’s preferences over the horizontal and vertical
attributes varies with the parameter \( \beta \). In particular, consider the following three cases:

Case I: \( \beta = -1 \) \( \Rightarrow \) \( \Pr(\theta_i = \theta | X_i) = 1 - X_i \) and \( \Pr(\theta_i = 0 | X_i) = X_i \)

Case II: \( \beta = 0 \) \( \Rightarrow \) \( \Pr(\theta_i = \theta | X_i) = \frac{1}{2} \) and \( \Pr(\theta_i = 0 | X_i) = \frac{1}{2} \)

Case III: \( \beta = 1 \) \( \Rightarrow \) \( \Pr(\theta_i = \theta | X_i) = X_i \) and \( \Pr(\theta_i = 0 | X_i) = 1 - X_i \)

In Case I, quality-lovers are more likely to live close to firm \( A \) at \( L_A = 0 \), which produces a low-quality

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11 Note that \( \Pr(\theta_i = \theta | X_i) + \Pr(\theta_i = 0 | X_i) = 1 \).
product $Q_i = q_i$. In this case, we say that $X_i$ and $\theta_i$ are “negatively” correlated. In Case III, quality-neutrals are more likely to live close to firm $A$ and we say that $X_i$ and $\theta_i$ are “positively” correlated. Finally, in Case II, quality-lovers and quality-neutrals are equally likely to live close to either product and we say that $X_i$ and $\theta_i$ are uncorrelated or are “orthogonal” to each other. As $\beta$ varies from -1 to 1, the correlation between $X_i$ and $\theta_i$ goes from being negative to positive.

To complete the model, we need to take a stand on what consumers and firms know about product attributes. We assume consumers possess perfect information about their preferences over quality, their own locations, and the locations of firms. However, consumers are assumed not to know, a priori, the quality of a particular firm’s product, at least not without a firm disclosing it. Consumers do know the distribution of quality levels in the market. That is, without additional information, consumers believe both products are of the same quality, i.e., $E(Q) = \frac{q_h + q_l}{2}$. Furthermore, we assume that consumers do not know how other consumers are distributed with respect to their tastes, i.e., they do not know the conditional probabilities in (2) and (3). We think this latter assumption, though restricting the ability of consumers to make inferences about product quality from knowledge of where consumers are located and firms’ disclosure decisions, is reasonable. We leave to future work any relaxation of this assumption. Finally, we assume that firms know the quality of their rival’s product and they both know the distribution of consumer tastes, i.e., they do know the conditional probabilities in (2) and (3).

2.2 Disclosure Technology and Game Structure

We assume that there exists a truthful, accurate, and costless disclosure mechanism for sellers to disclose the quality dimension of their products. For example, a non-profit certification agency offers free services to firms who want to provide information. In our duopoly model, if neither firm uses this mecha-

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12 This means, consumers know that a given firm’s product is either high or low quality, and both levels of quality are offered in the market.
nism, the only information consumers have is the distribution of qualities. However, if either firm stands out and discloses its quality, consumers know the quality of this firm as well as the other firm.\(^{13}\)

To characterize the timing of firm decisions, we adopt a two-stage dynamic game. In the first stage, firms decide on disclosure simultaneously. In the second stage, firms engage in Bertrand competition to maximize profits and consumers choose which product to purchase to maximize their utility. Consumers’ valuations of products are conditional on product prices and what they have inferred about the quality of these products.

The essence of this two-stage game is that each firm makes its first-stage disclosure decisions, considering the resulting price competition between firms in the second stage. We solve for a sub-game perfect Nash equilibrium using backward induction. That is, a firm evaluates its payoff (profits) in the second stage under various information scenarios, which are determined by firms’ disclosure decisions in the first stage. The firm then eliminates the first-stage strategy that yields its worse final payoff, taking its rival’s first-stage and second-stage responses into consideration. By construction, there can only be two information scenarios—one is that neither firm discloses the quality of its product so that consumers have no information; the other is that one or both firms disclose their quality so that consumers have full information. We refer to the payoffs under the first scenario as “non-disclosure outcomes” and those under the second scenario as “disclosure outcomes”. As illustrated in the following table, if both firms choose silence, they will face the non-disclosure outcomes. If either firm speaks out, they will face disclosure outcomes, regardless of the other firm’s action. A firm’s disclosure decision boils down to comparing the profit it would receive under the disclosure and non-disclosure scenarios. If both firms’ payoffs associated with the non-disclosure scenario are better than those in the disclosure case, both will stick with non-disclose.\(^{14}\) Thus the subgame-perfect Nash equilibrium will be [non-disclosure, non-disclosure]. If either firm’s payoff is better in the disclosure scenario, the equilibrium will be [disclosure, non-disclosure] and

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\(^{13}\) If a high-quality firm discloses itself, consumers will infer the other firm in the market is of low-quality, because consumers know the quality distribution. The same logic holds vice versa.

\(^{14}\) We assume if a firm is indifferent between non-disclosure and disclosure, it always chooses non-disclosure. A useful way to think about this is that disclosure is associated with an arbitrarily small cost.
information unravels in this market.

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In section 2.3 to 2.5, we will show how the outcomes, and as a result, the equilibrium, critically hinges on the nature of consumer heterogeneity, i.e., different parameter values of $\beta$, $\lambda$, and $\theta$.

### 2.3 Firm Outcomes under Non-Disclosure

We first consider the purchase choices of consumers when no firm opts to disclose the quality of its product. Since consumers can not tell the quality difference between the two products, a consumer will only evaluate prices and transportation costs when deciding on purchase. Consumers who live close to firm $A$ will tend to buy product $Y_A$, holding prices of both products constant. We can derive that consumers at location $X$ will purchase $Y_A$ if and only if $2\lambda X \leq P_B - P_A + \lambda$. This is the standard result in the Hotelling model of product differentiation. It follows that the best-response functions for the two firms are

\[
P_{A,\text{non-disclosure}}^{BR} = 0.5(P_B + \lambda) \tag{4}
\]

\[
P_{B,\text{non-disclosure}}^{BR} = 0.5(P_A + \lambda) \tag{5}
\]

and that the prices charged by the two firms in equilibrium are

\[
P_{A,\text{non-disclosure}}^* = P_{B,\text{non-disclosure}}^* = \lambda. \tag{6}
\]

That is, in equilibrium of this static pricing-setting game with no information about product quality, the two firms charge the same prices, split the market equally, and earn a profit of $0.5\lambda$ respectively.
2.4 Firm Outcomes under Disclosure

We now consider the scenario under which consumers have perfect information about the quality of both products as a result of either firm’s disclosure. We will derive the disclosure outcomes under alternative assumptions about consumer preferences and compare them to the non-disclosure outcomes. We first consider quality-lovers and quality-neutrals separately and we have:

- If a consumer is a quality-neutral ($\theta_i = 0$), she will purchase the low-quality product $Y_A = Y(0, q_i)$ if and only if $X_i \leq \frac{P_B - P_A + \lambda}{2\lambda}$ and the high-quality product $Y_B = Y(0, q_h)$ if and only if $X_i > \frac{P_B - P_A + \lambda}{2\lambda}$.

- If a consumer is a quality-lover ($\theta_i > 0$), she will purchase the low-quality product $Y_A$ if and only if $X_i \leq \frac{P_B - P_A + \lambda - \theta \Delta}{2\lambda}$ and the high-quality product $Y_B$ if and only if $X_i > \frac{P_B - P_A + \lambda - \theta \Delta}{2\lambda}$.

The different purchase decisions of two different types of consumers are illustrated in Figure 1.
Figure 1

In Figure 1, the horizontal axis represents the location of consumers, while the vertical axis represents the probability that a quality-lover lives at location $X$. The negatively-sloped line that cuts the figure divides the $(X, \Pr(\theta))$ space into area $C_1 + C_4$ (quality-lovers) and area $C_2 + C_3$ (quality-neutrals).

This figure depicts the situation in which $X_i$ and $\theta_i$ are “negatively” correlated---quality-lovers have a larger mass close to the low-quality firm. We denote the shaded area---$C_1 + C_2$---as $s_A$, which is the proportion of consumers buying the lower-quality product $Y_A$. We denote the unshaded area---$C_3 + C_4$---as $s_B$, which is the proportion buying the higher-quality product $Y_B$. Algebraically, these market shares are given by:

$$s_A = \text{area}(C_1) + \text{area}(C_2)$$

$$= \frac{1}{2} \left( 1 - \beta + \beta \frac{P_B - P_A + \lambda - \theta \Delta}{2 \lambda} \right) \left( \frac{P_B - P_A + \lambda - \theta \Delta}{2 \lambda} \right) + \frac{1}{2} \left( 1 - \beta \right) \left( \frac{P_B - P_A + \lambda}{2 \lambda} \right) \left( \frac{P_B - P_A + \lambda}{2 \lambda} \right) \tag{7}$$

$$= \left( 1 - \frac{\beta \theta \Delta}{2 \lambda} \right) \left( \frac{P_B - P_A + \lambda}{2 \lambda} \right) + \frac{\beta \theta^2 \Delta^2}{8 \lambda^2} - \left( 1 - \beta \right) \frac{\theta \Delta}{4 \lambda}$$

$$s_B = \text{area}(C_3) + \text{area}(C_4) = 1 - s_A$$

$$= -\left( 1 - \frac{\beta \theta \Delta}{2 \lambda} \right) \left( \frac{P_B - P_A + \lambda}{2 \lambda} \right) - \frac{\beta \theta^2 \Delta^2}{8 \lambda^2} + \left( 1 - \beta \right) \frac{\theta \Delta}{4 \lambda} + 1 \tag{8}$$

And the profit functions for both firms, assuming no production costs, are given by:

$$\pi_A = P_A s_A \tag{9}$$

$$\pi_B = P_B s_B \tag{10}$$

To ensure that there are maximal values of profit functions, that prices are strategically complementary, and that there is a unique and stable price equilibrium, we assume that $\theta \Delta < \lambda$. To be short, this assumption ensures that the profit functions are well defined.

The following first-order conditions characterize the firms’ profit maximizing problems:
\[ s_A - P_A \left[ 1 - \frac{\beta \theta \Delta}{2 \lambda} \right] = 0, \]  
\[ s_B - P_B \left[ 1 - \frac{\beta \theta \Delta}{2 \lambda} \right] = 0. \]  

The conditions in (11) and (12) imply the following best-response functions:

\[ P^{BR, disclosure}_A = \frac{1}{2} \left( P_B + \lambda + \frac{\beta \theta^2 \Delta^2 - 2 \lambda (1 - \beta) \theta \Delta}{4 \lambda - 2 \beta \theta \Delta} \right) = \frac{1}{2} \left( P_B + \lambda + \frac{\theta \Delta}{2} (1 - \omega) \right) \]  
\[ P^{BR, disclosure}_B = \frac{1}{2} \left( P_A + \lambda + \frac{-\beta \theta^2 \Delta^2 + 2 \lambda (1 + \beta) \theta \Delta}{4 \lambda - 2 \beta \theta \Delta} \right) = \frac{1}{2} \left( P_A + \lambda + \frac{\theta \Delta}{2} (1 + \omega) \right), \]  

where \( \omega = \frac{2 \lambda \beta}{2 \lambda - \beta \theta \Delta} \), and the equilibrium prices for the two products are given by:

\[ P^{\text{disclosure}}_A = \lambda + \frac{\theta \Delta}{6} \left( \frac{6 \lambda \beta - (2 \lambda - \beta \theta \Delta)}{2 \lambda - \beta \theta \Delta} \right) = \lambda + \frac{\theta \Delta}{2} \left( \omega - \frac{1}{3} \right) \]  
\[ P^{\text{disclosure}}_B = \lambda + \frac{\theta \Delta}{6} \left( \frac{6 \lambda \beta + (2 \lambda - \beta \theta \Delta)}{2 \lambda - \beta \theta \Delta} \right) = \lambda + \frac{\theta \Delta}{2} \left( \omega + \frac{1}{3} \right). \]  

It follows from (15) and (16) that:

\[ P^{\text{disclosure}}_A + P^{\text{disclosure}}_B = \frac{2 \lambda \beta}{\beta}, \]  
\[ P^{\text{disclosure}}_B - P^{\text{disclosure}}_A = \frac{\theta \Delta}{3}. \]  

It also follows from (15) and (16) that that the profits of the two firms under disclosure are:

\[ \Pi^{\text{disclosure}}_A = P^{\text{disclosure}}_A s^{\text{disclosure}}_A = \frac{1}{2} \lambda \left[ 1 + \frac{\theta \Delta}{2 \lambda} \left( \omega - \frac{1}{3} \right) \right] \left[ 1 + \frac{\theta \Delta}{2 \lambda} \left( \frac{\beta \theta \Delta}{6 \lambda} - \frac{1}{3} \right) \right] \]  
\[ \Pi^{\text{disclosure}}_B = P^{\text{disclosure}}_B s^{\text{disclosure}}_B = \frac{1}{2} \lambda \left[ 1 + \frac{\theta \Delta}{2 \lambda} \left( \omega + \frac{1}{3} \right) \right] \left[ 1 + \frac{\theta \Delta}{2 \lambda} \left( -\frac{\beta \theta \Delta}{6 \lambda} + \frac{1}{3} \right) \right] \]
2.5 Firms’ Disclosure Decisions in Equilibrium

Comparing firm outcomes under the two scenarios, we are able to show that compared to the non-disclosure case:

1) If \[-\frac{2\lambda}{2\lambda + \theta\Delta} \leq \omega < -\frac{1}{3},\] or equivalently, \[-1 \leq \beta < \frac{-2\lambda}{6\lambda - \theta\Delta},\] disclosure by either firm will cause both firms’ prices to fall.

2) If \[-\frac{1}{3} \leq \omega \leq \frac{1}{3},\] or equivalently, \[-2\frac{\lambda}{6\lambda - \theta\Delta} < \beta < \frac{2\lambda}{6\lambda + \theta\Delta},\] disclosure by either firm will cause \(P_B\) to rise and \(P_A\) to fall.

3) If \[\frac{1}{3} < \omega \leq \frac{2\lambda}{2\lambda - \theta\Delta},\] or equivalently, \[\frac{2\lambda}{6\lambda + \theta\Delta} < \beta \leq 1,\] disclosure by either firm will cause both firms’ prices to rise.

At the same time, with respect to firms’ profit we can show that compared to the non-disclosure case:

1) If \[-\frac{2\lambda}{2\lambda + \theta\Delta} \leq \omega < -\frac{5}{6},\] or equivalently, \[-1 \leq \beta < \frac{-10\lambda}{12\lambda - 5\theta\Delta},\] disclosure by either firm will cause both firms’ profits to fall. \(^{17}\)

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\(^{15}\) We can show that: \[-\frac{2}{5} \leq \frac{-2\lambda}{6\lambda - \theta\Delta} \leq -\frac{1}{3}.\]

\(^{16}\) We can show that: \[0 < \frac{2\lambda}{6\lambda + \theta\Delta} \leq \frac{1}{3}.\]

\(^{17}\) Proof:

\[-\frac{2\lambda}{2\lambda + \theta\Delta} \leq \omega < -\frac{5}{6} \Rightarrow -\frac{2}{3} \leq \omega + \frac{1}{3} < -\frac{1}{2},\] and \[\frac{1}{3} < \frac{\beta\theta\Delta}{6\lambda} + \frac{1}{3} \leq \frac{1}{2}.\] It follows that

\[0 < \frac{\theta\Delta}{2\lambda} \left( -\frac{\beta\theta\Delta}{6\lambda} + \frac{1}{3} \right) < \frac{\theta\Delta}{2\lambda} \left( \omega + \frac{1}{3} \right)\]

and we can show that:

\[\Pi^{\text{non-disclosure}}_A = \frac{1}{2} \left[ 1 + \frac{\theta\Delta}{2\lambda} \left( \omega + \frac{1}{3} \right) \right] \left[ 1 + \frac{\theta\Delta}{2\lambda} \left( \frac{\beta\theta\Delta}{6\lambda} + \frac{1}{3} \right) \right] \left[ 1 - \frac{\theta\Delta}{2\lambda} \left( \omega + \frac{1}{3} \right) \right] < \frac{1}{2}.\]

At the same time, \[-\frac{2\lambda}{2\lambda + \theta\Delta} \leq \omega < -\frac{5}{6} \Rightarrow \omega + \frac{1}{3} < 0,\] and \[\frac{\beta\theta\Delta}{6\lambda} + \frac{1}{3} < 0\], and

\[\Pi^{\text{non-disclosure}}_A = \frac{1}{2} \left[ 1 + \frac{\theta\Delta}{2\lambda} \left( \omega - \frac{1}{3} \right) \right] \left[ 1 + \frac{\theta\Delta}{2\lambda} \left( \frac{\beta\theta\Delta}{6\lambda} - \frac{1}{3} \right) \right] < \frac{1}{2}.\]
2) If $-\frac{5}{6} \leq \omega \leq \frac{11}{15}$, or equivalently, $\frac{-10\lambda}{12\lambda - 5\theta\Delta} \leq \beta \leq \frac{22\lambda}{30\lambda + 11\theta\Delta}$, disclosure by either firm will cause $\Pi_B$ to rise and $\Pi_A$ to fall.

3) If $\frac{11}{15} < \omega \leq \frac{2\lambda}{2\lambda - \theta\Delta}$, or equivalently, $\frac{22\lambda}{30\lambda + 11\theta\Delta} < \beta \leq 1$, disclosure by either firm will cause both firms’ profits to rise.  

As the above results make clear, the equilibrium prices and profits under the disclosure scenario depend on the joint distribution of consumer locations and their preferences for quality. As the correlation of $X_i$ and $\theta_i$ goes from being negative to positive, disclosure by either firm will, in terms of profits, first make both worse-off, then make the low-quality firm worse-off and the high-quality firm better-off, and finally make both firms better-off. More formally, we formulate the following proposition concerning firms’ disclosure decisions:

**PROPOSITION:** The decision of either firm to disclose the quality of its product can cause the prices and profits of both firms to fall. As a result, both firms will choose not to disclose their private information about product quality.

**Proof:** As long as $\omega < -\frac{1}{3}$, i.e., $\beta < \frac{-2\lambda}{6\lambda - \theta\Delta}$, disclosure from either firm will cause the prices of both firms to fall relative to the price levels under the non-disclosure scenario. Furthermore, profits will fall

---

18 Proof: $\frac{11}{15} < \omega \leq \frac{2\lambda}{2\lambda - \theta\Delta} \Rightarrow \omega - \frac{1}{3} > \frac{2}{5}$, and $\frac{\beta\theta\Delta}{6\lambda} - \frac{1}{3} \geq -\frac{1}{3}$. Then we can show:

\[
\Pi^\text{disclosure}_A = \frac{1}{2} \left[ 1 + \frac{\theta\Delta}{2\lambda} \left( \omega - \frac{1}{3} \right) \right] \left[ 1 + \frac{\theta\Delta}{2\lambda} \left( \frac{\beta\theta\Delta}{6\lambda} - \frac{1}{3} \right) \right] > \frac{1}{2} \left[ 1 + \frac{\theta\Delta}{2\lambda} \left( \frac{2}{5} \right) \right] \left[ 1 + \frac{\theta\Delta}{2\lambda} \left( -\frac{1}{3} \right) \right] > \frac{1}{2}.
\]

At the same time $\frac{11}{15} < \omega \leq \frac{2\lambda}{2\lambda - \theta\Delta} \Rightarrow \omega + \frac{1}{3} > 0$ and $-\frac{\beta\theta\Delta}{6\lambda} + \frac{1}{3} > 0$, and we can show:

\[
\Pi^\text{disclosure}_B = \frac{1}{2} \left[ 1 + \frac{\theta\Delta}{2\lambda} \left( \omega + \frac{1}{3} \right) \right] \left[ 1 + \frac{\theta\Delta}{2\lambda} \left( \frac{\beta\theta\Delta}{6\lambda} + \frac{1}{3} \right) \right] > \frac{1}{2}.
\]
for both firms when \( \beta \) is sufficiently negative, that is, when \( \beta < \frac{-10\lambda}{12\lambda - 5\theta\Delta} \). Under this circumstance, either firm will choose not to disclose information in anticipation of its rival’s response, and the subgame-perfect Nash equilibrium is [non-disclosure, non-disclosure]. \textit{Q.E.D.}

To better understand this proposition, we consider how the firms’ best-response functions under the disclosure scenario are affected by the correlation between consumer locations and their preferences for quality. When \( \beta = -1 \), the best-response functions are:

\[
P^\text{BR, } \beta = -1_A = \frac{1}{2} \left[ P_B + \lambda - \frac{1}{2} \theta\Delta \left( 1 + \frac{2\lambda}{2\lambda + \theta\Delta} \right) \right]
\]

(19)

\[
P^\text{BR, } \beta = -1_B = \frac{1}{2} \left[ P_A + \lambda + \frac{1}{2} \theta\Delta \left( 1 - \frac{2\lambda}{2\lambda + \theta\Delta} \right) \right],
\]

(20)

When \( \beta = 1 \), the best-response functions are:

\[
P^\text{BR, } \beta = 1_A = \frac{1}{2} \left[ P_B + \lambda - \frac{1}{2} \theta\Delta \left( 1 - \frac{2\lambda}{2\lambda - \theta\Delta} \right) \right]
\]

(21)

\[
P^\text{BR, } \beta = 1_B = \frac{1}{2} \left[ P_A + \lambda + \frac{1}{2} \theta\Delta \left( 1 + \frac{2\lambda}{2\lambda - \theta\Delta} \right) \right].
\]

(22)

In the general case, the best-response functions are a weighted average of those given in (19), (20), (21), and (22):

\[
P^\text{BR}_A = \alpha P^\text{BR, } \beta = -1_A + (1 - \alpha) P^\text{BR, } \beta = 1_A
\]

(23)

\[
P^\text{BR}_B = \alpha P^\text{BR, } \beta = -1_B + (1 - \alpha) P^\text{BR, } \beta = 1_B
\]

(24)

where \( \alpha = \frac{1 - \beta}{2\lambda - \beta\theta\Delta} \) and \( \alpha \in [0,1] \).\(^{19}\)

These above decomposition of firms’ best response functions are illustrated in Figure 2.

\(^{19}\) Note that \( \frac{\partial \alpha}{\partial \beta} = -\frac{4\lambda^2 - \theta^2\Delta^2}{(2\lambda - \beta\theta\Delta)^2} < 0 \). When \( \beta = -1 \), \( \alpha = 1 \); when \( \beta = 1 \), \( \alpha = 0 \). Therefore \( \alpha \in [0,1] \).
In Figure 2, the intersection of $P_{A}^{BR}$ and $P_{B}^{BR}$ is the price equilibrium. The decomposition shows that any point along the bold line $LH$ can be supported as an equilibrium, given that $\alpha \in [0,1]$. Which equilibrium will be realized depends on parameter values $\beta$, $\lambda$, $\theta$, and $\Delta$. If, for example, $\beta = 1$ (corresponding to $\alpha = 0$), the equilibrium will be at point $H$ (the north-east corner of line $LH$), where the prices charged by both firms are higher under disclosure than those under non-disclosure. If $\beta = -1$ (corresponding to $\alpha = 1$), the equilibrium will be at point $L$ (the south-west corner of line $LH$), where the prices charged by both firms are lower under disclosure than those under non-disclosure.

As illustrated in Figure 2, from non-disclosure to disclosure the best-response curve for the low-quality product $Y_{A}$ may shift downward by a larger magnitude than that the corresponding curve for the high-quality product $Y_{B}$ shifts upward by. This will happen when $\beta$ is sufficiently negative. A region to the south-west corner of line $LH$ corresponds to the case that both firms lose profits due to disclosure and

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20 We have established that $P_{A}^{\text{Disclosure}} - P_{A}^{\text{Disclosure}} = \frac{\theta \Delta}{3}$. It follows that the price equilibria form a straight line independent of $\beta$. Any point on this line is a weighted average of two end points.
as a result, neither firm will voluntarily disclose the quality of its product.\footnote{This graphic illustration shares the similar intuition with Corts (1998), which investigates how price discrimination may lead to an all-worse-off results for firms ranking consumer groups differently.}

2.6 Comparative Statics: Other Dimensions of Consumer Heterogeneity

To this point, we have focused on how firms’ incentives to voluntarily disclose their unobserved quality varies with \( \beta \), which characterizes the correlation between consumers’ preferences on the observable and unobservable attribute. However, as we have noted at various points, our results with respect to whether voluntary disclosure occurs also depend on \( \lambda \) and \( \theta \), two other measures of consumer heterogeneity. In this section, we briefly consider how product prices vary with these two aspects of consumer preferences under different information scenarios.

We consider first how firm pricing decisions under disclosure changes as we change \( \theta \), which measures the spread of consumer heterogeneity on the quality dimension. The first order derivatives of disclosure prices with respect to \( \theta \) are:

\[
\frac{\partial P_A^{*\text{,disclosure}}}{\partial \theta} = \frac{\Delta}{2} \left( \frac{\omega^2}{\beta} - \frac{1 + \theta}{3} \right)
\]

\[
\frac{\partial P_B^{*\text{,disclosure}}}{\partial \theta} = \frac{\Delta}{2} \left( \frac{\omega^2}{\beta} + \frac{1 + \theta}{3} \right)
\]

We can show that the above two derivatives are negative when \( \beta \) is sufficiently negative. This implies that when \( \beta \) is sufficiently negative (positive), increasing the spread of consumer heterogeneity on quality will not only discourage (encourage) disclosure but also intensify (alleviate) price competition, leading to lower (higher) overall market price levels after disclosure.

Next we consider the effects of \( \lambda \), which measures the spread of consumer heterogeneity on the observed horizontal dimension. The first order derivatives of disclosure prices with respect to \( \lambda \) are:
\[
\frac{\partial P^*_{\text{disclosure}}}{\partial \lambda} = 1 - \left(1 - \frac{2\lambda}{2\lambda - \beta \Delta}\right)^2 > 0
\] (27)

\[
\frac{\partial P^*_{\text{disclosure}}}{\partial \lambda} = 1 - \left(1 - \frac{2\lambda}{2\lambda - \beta \Delta}\right)^2 > 0
\] (28)

The above implies that product prices under disclosure increase with \(\lambda\). That is, the higher transportation costs are, the higher will be the overall market price levels after disclosure. Note, however, that this prediction also holds under the nondisclosure scenario. In short, greater consumer heterogeneity along the observed attributes of products tends to increase product prices, independent of consumers’ possession of information on the quality attributes.

To summarize, we have shown via a simple model that firms’ disclosure incentives as well as market outcomes under different information scenarios critically hinges on the nature of consumer heterogeneity determined by different parameter values of \(\beta\), \(\lambda\), and \(\theta\). A note of caution: in our model consumer heterogeneity with respect to their tastes for quality is captured in a simple, dichotomous way, with only two types of consumers allowed. Therefore in the Appendix, we examine the robustness of our findings on firm prices, profits, and their incentives to disclose product quality. We will allow for a continuum of types of consumers with respect to their preferences over the quality attribute and show that the thrust of our findings is not sensitive to variants of the simple set up of our model.

3. **Intuitions and Implications**

Before disclosure, consumers are forced to choose products in the absence of information on all attributes of a product. This will potentially give rise to a mismatch of consumers and products. In contrast, full information allows consumers to assess the entire bundle of attributes contained in each product and, as a result, assess their willingness to pay for each product more accurately. But, as the results in the previous section make clear, allowing consumers to make such assessment may not always be in the interests of
firms. More information may change the substitutability of products and make consumers more sensitive to the prices charged by firms, which firms want to avoid. In this section, we offer more general implications of our findings by relating firms’ strategic disclosing behavior to how information changes the elasticities of demand for multi-attribute products.

3.1 Product Substitution Patterns and Demand Elasticities

Our results indicate that whether disclosure reduces the price responsiveness of consumers for a product relies on how consumers’ tastes for quality and their location vis-à-vis firms are jointly distributed. To pinpoint this point, we need to describe the elasticities of demand for products $Y_A$ and $Y_B$ with and without quality disclosure. Consider first the demand elasticities for the two products under the non-disclosure scenario. In the general case where $P_A = P_B = P$, these elasticities are given by:

$$e_{A,\text{non-disclosure}} = \frac{-\partial s_A}{\partial P_A} \frac{P}{s_A,\text{non-disclosure}} = \frac{P}{\lambda}, \quad e_{B,\text{non-disclosure}} = \frac{-\partial s_B}{\partial P_B} \frac{P}{s_B,\text{non-disclosure}} = \frac{P}{\lambda}. \quad (29)$$

As $P_A = P_B = \lambda$, $e_{A,\text{non-disclosure}} = e_{B,\text{non-disclosure}} = 1$. When prices are below (above) the equilibrium level $\lambda$, both firms want to increase (decrease) their prices because $e_{j,\text{non-disclosure}} < 1$ ($e_{j,\text{non-disclosure}} > 1$).

Under the disclosure scenario, the demand elasticities for the two products are given by:

$$e_{A,\text{disclosure}} = \frac{P_A \left(1 - \frac{\beta \theta \Delta}{2\lambda} \right)}{\left(1 - \frac{\beta \theta \Delta}{2\lambda} \right) \left( \frac{P_B - P_A + \lambda}{2\lambda} + \frac{\beta \theta \Delta^2}{8\lambda^2} \right) - \left(1 - \beta \right) \frac{\theta \Delta}{4\lambda}}$$

$$= \left( \frac{\beta}{2\lambda \omega} \right) \left( \frac{P_A}{\frac{\beta}{2\lambda \omega} \left( P_B - P_A + \lambda \right) + \frac{\beta \theta \Delta}{4\lambda} \left( 1 - \frac{1}{\omega} \right)} \right)$$

$$= \frac{P_A}{\left( P_B - P_A + \lambda \right) + \frac{\theta \Delta}{2} (\omega - 1)} \quad (30)$$

and
respectively. At $P_A = P_B = \lambda$, $e_A^{\text{disclosure}} = \left(1 + \frac{\theta \Delta}{2 \lambda} (\omega - 1)\right)^{-1}$, and $e_B^{\text{disclosure}} = \left[-1 - \frac{\theta \Delta}{2 \lambda} (\omega - 1) + \frac{2 \omega}{\beta}\right]^{-1}$. 

Suppose one firm discloses its quality and we have a change of regime from non-disclosure to disclosure. As long as $\beta < \frac{2 \lambda}{2 \lambda + \theta \Delta}$, $e_A^{\text{disclosure}} > 1$. That is, the elasticity of demand for the low-quality product is more than unitarily elastic, and the low-quality firm needs to lower its price in order to avoid losing consumers. At the same time, $e_B^{\text{disclosure}} = \left[-1 - \frac{\theta \Delta}{2 \lambda} (\omega - 1) + \frac{2 \omega}{\beta}\right]^{-1} < 1$, which is why the best-response curve of the high-quality firm always shifts up after disclosure. But, when $\beta$ becomes sufficiently negative, the elasticity of demand for the high-quality product, $e_B^{\text{disclosure}}$, will become greater than unity as the low-quality firm cuts its price. Traditional wisdom dictates that greater demand elasticity is associated with more substitutability among products, and thus with more intense price competition.

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22 This inequality is equivalent to $\beta > -\left(1 - \frac{\theta \Delta}{2 \lambda}\right)^{-1}$, which holds because $\left(1 - \frac{\theta \Delta}{2 \lambda}\right)^{-1} > 1$ and $\beta \in [-1,1]$. 

23 When $P_B = \lambda$, $e_A^{\text{disclosure}} = \left[P_A - 2 \frac{\theta \Delta}{2 \lambda} (\omega - 1) + \frac{2 \omega}{\beta}\right]^{-1}$. If $\beta < \frac{2 \lambda}{\theta \Delta} \left[1 - \left(2 - \frac{P_A}{\lambda} - \frac{\theta \Delta}{2 \lambda}\right)^{-1}\right]^{-1}$, $e_B^{\text{disclosure}} > 1$. This implies when the low-quality firm lowers its price $P_A$ relative to its non-disclosure level $\lambda$, a sufficiently negative $\beta$ will make the demand elasticity for the high quality product greater than unity.
among firms. Therefore revelation of a quality attribute, generating greater product substitutability and intensifying price competition, might result in price as well as profit decreases for all firms.

To probe this issue further, we notice that consumers are systematically “mismatched” with respect to location and tastes for quality when $X_i$ and $\theta_i$ are negatively correlated. Quality-lovers, on average, are located closer to the low-quality product (sold by Firm $A$) and quality-neutrals are located closer to the high-quality product (sold by Firm $B$). To put it in another way, the “home” market for the low-quality product is disproportionately made up of quality-lovers. Upon disclosure, consumers, recognizing this mismatch, will be less willing to pay higher prices for products near to them than they were when location was the only attribute of the product on which they based their purchase. They will want to get compensated for the mismatch in location and quality by lower prices firms offer and become more price sensitive in their demand for products. Similar intuition can be developed about the case that $X_i$ and $\theta_i$ are positively correlated, only it works in the opposite direction.

As is well known from the literature on product differentiation, firms have strategic incentives to differentiate their products when such differentiation reduces demand elasticities of their products and alleviate price competition with rivals selling otherwise similar products. Disclosing information on product quality can precisely achieve the effect of differentiating the product of a firm from that of its competitor when the unobserved quality is the single dimension of product differentiation. However, this is not true when there pre-exists another product attribute. In our model, from the perspective of consumers, both products are fully differentiated by their locations, as the two firms are located at opposite ends of the linear city. Even with no information about product quality, each firm already faces a downward sloping demand curve for its product. Consumers do not view the two products as perfect substitutes and firms selling such differentiated products earn positive profits. With the existing horizontal differentiation, a firm’s incentive to differentiate its product along another dimension, via disclosure, will be complicated and strategically driven.
3.2 An Illustration

Here we discuss a hypothetical situation to intuitively explain our results. Suppose there are two restaurants in a market: one is a fast food outlet specializing in hamburgers; the other is a French restaurant featuring fancy dishes like escargot. Two types of consumers----students and professors----populate this market. At the same price for a meal, we suppose that, on average, students prefer hamburgers to French cuisine to save time for studying, while professors, who have more sophisticated palettes, have the opposite tastes.

The two restaurants differ in their hygienic practices. Suppose, in fact, that the fast food restaurant maintains a very sanitary kitchen, while the French restaurant’s hygienic practices are more lax. Neither type of consumers, on their own, can readily determine the hygienic quality of the restaurants. To warn the malpractices and ensure food safety, the local public health department inspects restaurants and rates their hygiene quality. However, the department only discloses the ratings to the restaurants instead of the general public. The restaurants have the freedom to disclose the hygiene ratings they receive by posting them on the window or at the entrance of their restaurants.

Under what circumstances will one or both of the restaurants choose to post their ratings? Our model indicates that this depends on the distribution of consumer tastes for the two types of cuisine and for the hygiene quality. Recall that professors, on average, prefer French cuisine to fast food and students fast food to French cuisine. Let’s first consider the case when students have stronger preferences for better hygienic practices than do professors. Using the terminology we developed, preferences for hygiene and tastes for food are “positively” correlated. That is, those who have stronger preferences for hygiene also prefer the taste of the more sanitary food, and those who have weaker preferences for hygiene also prefer the taste of the less sanitary food. Under this distribution of preferences, the fast food restaurant may want post its better hygiene rating. These two restaurants, upon disclosure, become less substitutable

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24 This example is inspired Jin and Leslie (2003), who study restaurants’ hygiene practices under different disclosure requirements in Los Angeles county.

25 For example, the Los Angeles County Department of Public Health issued hygiene “grade cards” to restaurants and, in some areas of the county, allowed restaurants the choice of whether or not to display them.
for students and professors. For students, the fast food restaurant offers the food they prefer and better hygiene so that they have no incentives to switch restaurants. Professors are content to stay with the French restaurant too. Upon disclosure the degree of price competition between the two restaurants will be actually reduced due to the decline in substitutability between the two restaurants. Both firms potentially gain from this relaxation of competition and, in turn, from posting their hygiene ratings.

Now let’s consider the opposite scenario: professors value the hygiene quality more than do students. That is, while professors prefer French cuisine to fast food, they also prefer better hygiene—something that the French restaurant lacks; students, who prefer hamburgers, do not place high value on better hygienic practices, at which the fast food restaurant excels. Will the fast food restaurant still want to post its better hygiene rating?

Suppose the fast food restaurant does post its rating. Naturally, some professors, who value French food less strongly than other professors (and/or who value hygiene quality more strongly than others), want to switch to the fast food outlet upon learning that it maintains more sanitary conditions. In response, the French restaurant may want to mark down its price to lure back its consumer base. This move, however, will affect the fast food outlet’s market share, as some students, who value hamburgers less strongly than other students (and/or who value hygiene quality less strongly than others), will be willing to switch to the French restaurant for cheaper meals. In turn, the fast food outlet may also want to make down its menu, which may induce further price-cutting by the French restaurant. In the end, both restaurants would end up with lower prices and profits if the fast food restaurant were to disclose. Thus disclosing its hygiene rating is not in the fast food restaurant’s self-interest, nor in the French restaurant’s. Under this distribution of consumer preferences, voluntary disclosure will not occur in this market, even though both professors and students may be better off by having information on hygiene quality prior to deciding where to dine.

What is central to this second scenario is that consumers value both the horizontal attribute (taste

26 Professors, say, cannot afford to miss the classes they teach due to food poisoning while students do not mind missing a few of those classes, even if they have to spend the time in the student infirmary!
of food, or time saving) and a vertical attribute (hygiene quality) of the product (a meal outside the home). If consumers know both attributes of the meals the two restaurants are serving, they will choose to trade off their preferred meals for sanitary conditions and both will need to be compensated for poorer hygiene or less enjoyable taste. Under this configuration of consumer preferences, disclosure increases the substitutability between the two types of meals, intensifies price competition, and lowers profits for both restaurants. This makes disclosure undesirable for the restaurant serving more sanitary food.

4. Conclusion

Effective provision of information ensures the efficiency of market operations and benefits social welfare in a variety of ways. Researchers, consumer groups, and policy makers are debating about mandatory disclosure laws in various fields, most recent examples including genetically-modified food, restaurant hygiene, and medical errors. If the “unraveling result” holds, voluntary disclosure, as long as it is verifiable and of trivial costs, will achieve the same effects as mandatory disclosure requirement. Therefore, we should not expect to see any systematic change in disclosure behaviors, prices, and profits of firms when disclosure mechanisms—either from voluntary to mandatory or visa-versa—change.

This paper cast doubts on this ideal picture, taking into account multiple product attributes, consumer heterogeneity, and firms’ strategic behavior. We are able to show that firms do not always have full incentives to voluntarily disclose information on product quality as more information might cause more elastic demand and thus intensify price competition among firms. This implies that government intervention, such mandatory disclosure laws, may change firm behavior and benefit consumers in markets with incomplete information. In fact, recent empirical works (Mathios, 2000; Jin and Leslie, 2003) has shown that mandatory disclosure laws do make a difference and suggested that there might be lucrative motivation behind “a culture of silence”.27 More accurately, we show that mandatory disclosing laws

27 Quote Jin and Leslie (2003): “One may wonder why restaurants did not disclose the results of their hygiene inspections prior to the grade cards. Why would a restaurant manager not create their own poster clearly showing their latest hygiene score, say, and display it in the window? Perhaps this indicates it is unprofitable for restaurants to in-
may cause overall market prices to fall, if disclosure intensifies price competition. The more heterogeneous are consumers, the more prices will fall.\textsuperscript{28} This implication can be best tested if price data before and after regime change (say, a law mandating disclosure is put in force) are collected.

Furthermore, we find that market outcomes under different information scenarios are heavily influenced by the distribution of consumer multidimensional heterogeneity, which determines whether more informational flow will bring firm prices and profits up or down. Disclosure by some firms may exert an “externality” effect on their rivals. For example, in a market with a credible quality certification system, prices of uncertified firms may rise when their rivals receive certification. This is because price competition is alleviated due to product differentiation. This prediction is clearly different from what “the unraveling result” implies.

Finally, privately-informed firms’ decisions to reveal their quality should be considered as an integrated part of their location choice in the product space, which is constituted by an array of product attributes over which consumers have heterogeneous preferences. Firms, even with high quality, may want to avoid disclosure out of strategic considerations. Nothing concerning firms’ proprietary information can be so readily “unraveling”: a firm producing a product with a high-quality attribute may or may not reveal this attribute, depending on whether the revelation gives it the necessary “niche.” Future research should find out whether our results can be generalized to alternative, and more general, models of multiple product attributes and consumer heterogeneity.

\textsuperscript{28} Mandatory disclosing laws may as well cause overall market prices to rise, if disclosure alleviates price competition. The more heterogeneous are consumers, the more prices will rise.
References


Appendix: Continuous Consumer Preferences over Quality

In this appendix, we explore the robustness of our results by allowing a continuum of types of consumers with respect to their preferences over quality.

We hold the basic structure of the model unchanged: there are two firms occupying the two ends of a linear city. The distance between the two ends is 1 and consumers are indexed by \( X_i \) and are uniformly distributed along the real line characterizing the linear city. The firm at location 0 produces a product with low quality \( (q_l) \) while the one at location 1 produces a product with high quality \( (q_h) \). If a consumer at location \( X_i \) wants to buy the low-quality product, she has to incur a transportation cost of \( \lambda \ln X_i \), otherwise the transportation cost is \( \lambda \ln(1 - X_i) \).

The \( i^{th} \) consumer’s utility functions are specified as follows:

\[
U_{iA} = V + \theta_i q_l - \lambda \log X_i - P_A \\
U_{iB} = V + \theta_i q_h - \lambda \log(1 - X_i) - P_B .
\]

(32)

A consumer will buy the low-quality product \( (Y_A) \) if and only if \( U_{iA} > U_{iB} \), which implies:

\[
\theta_i \Delta + \lambda \log \frac{X_i}{1 - X_i} \leq P_B - P_A .
\]

Note that there is no dichotomous distinction of two groups of consumers so that we can better study how the relationship between \( \theta_i \) and \( X_i \) plays in the model. For simplicity, \( V \) is high enough so consumers will buy either product rather than nothing. We study three cases:

1) \( \theta_i \) and \( X_i \) are independently distributed.

2) \( \theta_i \) and \( X_i \) are positively correlated.

3) \( \theta_i \) and \( X_i \) are negatively correlated.

Let \( \theta_i = \overline{\theta} X_i^{1+\gamma} (1 - X_i)^{1-\gamma} \), where \( \gamma \in [-1,1] \) and \( \overline{\theta} \) measures the spread of consumer heterogeneity on

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29 We use the natural log in the transportation cost function for computing convenience.
quality. As \( \gamma \) ranges from -1 to 1, the correlation between \( \theta_i \) and \( X_i \) goes from being negative to positive. Similar to our previous notation, a positive (negative) correlation between \( \theta_i \) and \( X_i \) means that consumers who live closer to the low-quality product value quality less (more) than those who live close to the high-quality product. Independence between \( \theta_i \) and \( X_i \) means no above relationship exists.

There is no analytic solution to this model so we use simulation and graphs to display our results. These results are entirely consistent with our dichotomous model, as show by Figure A-1. In Figure A-1, on the horizontal axis is \( \gamma \), which measures the correlation between \( \theta_i \) and \( X_i \); on the vertical axes are profits, prices, and market shares, in panel A, B, and C respectively. We observe that, compared to market outcomes under non-disclosure:

1) when \( \theta_i \) and \( X_i \) are sufficiently positively correlated, disclosure leads to increased price levels and increased profits for both firms.

2) when \( \theta_i \) and \( X_i \) are sufficiently negatively correlated, disclosure leads to decreased price levels and decreased profits for both firms.

3) when the correlation between \( \theta_i \) and \( X_i \) is in between the above two cases, disclosure leads the high-quality firm to gain and the low-quality firm to lose.

Figure A-2 illustrates how prices, profits, and market shares of the two firms under disclosure depend on the degree of consumer heterogeneity along the quality dimension. On the horizontal axis is \( \overline{\theta} \), which measures the spread of consumer heterogeneity about quality; on the vertical axes are profits, prices, and market shares, in panel A, B, and C respectively. In this special case we show where \( \gamma = -1 \), meaning \( \theta_i \) and \( X_i \) are sufficiently negatively distributed, the more heterogeneous consumers are in their taste for quality, the lower are the overall market price and profit levels after disclosure.

\[30\] We notice \( \overline{\theta} \) shifts the mean of consumers’ quality preferences at the same time. But the main effect of \( \overline{\theta} \) should be on the variances.
Figure A-1  The Effects of $\gamma$ on Firm Profits, Prices, and Market Shares Before and After Disclosure

(Parameter Values Assumed: $\lambda = 1$, and $\Delta = \theta_h - \theta_l = 0.5$)

Panel A: Profits

Panel B: Prices

Panel C: Market Shares
Figure A-2  The Effects of $\bar{\theta}$ on Firm Profits, Prices, and Market Shares After Disclosure

(Parameter Values Assumed: $\gamma = -1$, $\lambda = 1$, and $\Delta = q_h - q_i = 0.5$)