Disclosing Multiple Product Attributes

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Abstract

A product often has many attributes. The seller of the product may choose whether to disclose these attributes to consumers before their purchase. How do multiple attributes of the product *jointly* determine the seller's disclosure incentives? I analyze this question by modeling a monopolist whose product is characterized by a vertical quality and a horizontal attribute. The monopolist does not always choose disclosure. When the product's vertical quality is common knowledge, a monopolist with a higher vertical quality is less likely to disclose the horizontal attribute. When both vertical quality and the horizontal attribute of the product are known only to the monopolist, he is more likely to choose disclosure when the vertical quality is higher. Nevertheless, the monopolist may choose nondisclosure even when his product has the highest possible vertical quality. The results shed light on mandatory disclosure policies and the design of quality surveys.

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1 Introduction

Product variety and complexity have both increased as the economy grows. Consumers, as a result, often have to choose among products that differ in many attributes. While information on products' existence and prices is relatively easy to acquire, it can be hard for consumers to find out which product provides them with the best match. Take, for example, computers, over-the-counter drugs, cars, tennis rackets, mattresses, etc.

Sellers can help consumers make more informed purchase decisions by disclosing product information. Traditionally, they may describe product attributes in advertisements, or encourage consumers to try their products by offering free samples and free returns. Recent developments in information technology have greatly reduced the cost of information disclosure. Sellers now can easily publish online a detailed description or third-party reviews of their products.[1] Information disclosure has become more feasible for sellers.

Empirical investigations provide interesting evidence on sellers' disclosure incentives. Jin and Leslie (2003) find that almost all restaurants in Los Angeles County voluntarily display hygiene cards. A hygiene card shows an aggregate grade on hygiene quality: "A" (90-100 percent), "B" (80-89 percent), "'C" (70-79 percent), or if the score is less than 70 percent the card reports the actual score.[2] Mathios (2000) finds that only half of the salad dressings wear nutrition labels before the national mandate, Nutrition Labeling and Education Act. Nutrition labels, rather than showing an aggregate grade, display information on multiple nutrient contents contained in the dressing: calories, total fat, cholesterol, sodium, carbohydrate and protein.[3]

Jin (2005) studies participation of Health Maintenance Organizations (HMOs) in two quality surveys.[4] The first survey evaluates each participating HMO's overall quality and assigns one of four possible statuses based on the extent to which it meets certain quality standards: full (valid for three years), one-year, provisional and denial. The second survey

[1] See Chen and Xie (2005) for a comprehensive study of third-party product reviews.

[2] See `www.stanford.edu/pleslie/restaurants` for photos of hygiene cards.

[3] See `http://www.fda.gov/opacom/backgrounders/foodlabel/newlabel.html` for a photo of the nutrition label.

[4] Both surveys are conducted by the National Committee for Quality Assurance (NCQA). The first survey is NCQA accreditation program. The second survey is Health Plan Employer Data and Information Set (HEDIS) joint with Member Satisfaction Survey (MSS).

evaluates and discloses each participating HMO's quality in multiple services, typically including breast cancer screening, diabetic eye exams, child immunization, and physician turnover rates.[5] The study finds that participation is not complete in either survey and the participation rate is consistently higher in the first survey.[6]

Empirical evidence suggests that sellers do not always voluntarily disclose product information. Moreover, their disclosure incentives depend on the amount and nature of the information that is being disclosed. The observation naturally leads to several questions. Which sellers disclose product information? How do multiple product attributes *jointly* determine sellers disclosure strategy? Does mandatory disclosure increase social welfare?

By analyzing the disclosure of multiple product attributes, this paper aims to provide some insights into these questions. While a product may have many attributes, they can often be summarized into two categories: vertical and horizontal. For example, the overall quality of an HMO is a vertical attribute in the sense that all consumers prefer it to be higher. The distribution of quality across different services is, on the other hand, a horizontal attribute: some consumers may prefer higher quality in eye exams while others care more about child care. As vertical and horizontal dimensions are general enough to cover most product attributes and easy to analyze, they have been the key elements in the literature of product differentiation.[7] In accordance with the literature, I model a fully informed monopolist whose product differs in both vertical quality and a horizontal attribute. By focusing on a monopolist, the model isolates disclosure's effects on price and demand from its possible effects on competition, so that the results do not rely on a particular market structure.

I first assume vertical quality to be common knowledge and analyze the monopolist's disclosure incentives on the horizontal attribute. The scenario best describes products that have been around long enough to have gained some quality reputation. The monopolist's equilibrium disclosure strategy follows a certain pattern. He discloses the horizontal attribute only when it is in a central region vis-à-vis consumer tastes. Consumers, upon

[5]See `http://web.ncqa.org/Portals/0/HEDISQM/HEDIS2007/MeasuresList.pdf` for the most recent list of measures.

[6]See Table 1 in Jin (2005) for a comparison of participation rates.

[7]See Becker (1965), Lancaster (1966), Muth (1966), Rosen (1974), Gorman (1980) and Tirole (1994).

seeing nondisclosure, do not know at which corner of the taste space the horizontal attribute is. The information asymmetry helps the monopolist to enlarge demand. As the horizontal attribute moves away from the center of the taste space, the demand enlargement effect increases and the monopolist is more likely to choose nondisclosure.

Interestingly, the monopolist is less likely to disclose the horizontal attribute when vertical quality is known to be higher. The intuition is as follows. A low-quality monopolist can hardly make any profit without ensuring some consumers a good match. A high quality monopolist, in contrast, aims to cover the entire market at a high price. He would have to lower the price if some consumers learn a bad match from disclosure, and hence chooses nondisclosure. I find preliminary evidence from the magazine and wine markets that supports the result.

I then examine the case in which both vertical quality and the horizontal attribute are privately known to the monopolist. The new scenario best describes new products or products that are frequently upgraded, such as computer software and skin-care products. The monopolist has the option to disclose all product information and faces a new tradeoff: the more he wants to disclose a high vertical quality, the more he wants to hide the horizontal attribute. Overall, he is more likely to choose disclosure when vertical quality is higher and the horizontal attribute is closer to the center of the consumer taste space. Nevertheless, monopolist may choose nondisclosure even when his product has the highest possible vertical quality. In the context of Mathios (2000) and Jin (2005), my results suggest that when a seller's product quality is high in some dimensions and low in others, he may choose nondisclosure even with a high overall quality.

The model yields two policy implications. First, mandatory disclosure may hurt both consumer welfare and the monopolist's profit. Second, as Jin and Leslie (2003) and Jin (2005) suggest, sellers are more likely to participate in quality surveys with one aggregate vertical measure than those with multiple measures. Conceptually, multiple quality measures disclose not only the overall quality but also the quality profile, a horizontal attribute. Consequently, survey designers should consider the tradeoff between a survey's informativeness and its participation rate.

The current paper extends "games of persuasion" in Grossman (1981) and Milgrom (1981). Their seminal papers establish the theory of "unraveling": if quality is unknown to consumers and a seller can credibly and costlessly disclose it, he always does. The logic is as follows. The seller with the highest quality always benefits from revealing his quality. Once he reveals his quality, the seller with the second highest quality benefits from revealing *his* quality. The process continues until every quality type is revealed. While Grossman (1981) and Milgrom (1981) acknowledge that monotonicity of buyer preference is necessary for unraveling to occur, my paper suggests that unraveling may fail with multiple quality attributes even when buyer preference is monotonic over each of these attributes.

Several studies have examined the robustness of unraveling. Most of these studies, however, do not consider privately known horizontal product attributes. Instead, they often focus on incomplete product information of the seller (Shin 1994), cost of product information acquisition and dissemination (Jovanovic 1982; Verrecchia 1983; Dye 1986; Matthews and Postlewaite 1985; Farrell 1986; Shavell 1994; Fishman and Hagerty 2003; Dye and Sridhar 1995; Stivers 2004), or disclosure's impact on competition (Okuno-fujiwama et al. 1990; Cheong and Kim 2004; Board 2005; Levin et al. 2005).

Hotz and Xiao (2007) consider horizontally differentiated products, but they assume that the horizontal attributes are known to consumers. They show that quality disclosure could intensify price competition in a later stage, and therefore firms may choose nondisclosure.[8] I allow the horizontal attribute to be privately known to the monopolist and focus on the interaction of multiple product attributes in determining disclosure incentives. My results hence do not rely on competition.

Seidmann and Winter (1997) study unraveling in a sender-receiver framework.[9] They assume that the sender cannot take any action other than sending a message and the receiver's best response is increasing in the sender's true type. The assumptions cna hardly be met in the context of product information disclosure. First, a seller sets the price besides disclosing product information. Second, a buyer's best response is not monotonic

[8] A similar reasoning appears in Chen and Xie (2005).

[9] See Crawford and Sobel (1982)'s seminal paper on cheap talk: disclosure of payoff-irrelevant information in a sender-receiver framework.

in the product's horizontal attribute.

This paper is also related to the literature of informative advertising.[10] Nelson (1974) first mentions that advertising can help match products to buyers. Subsequent studies often focus on comparing the market determined level of advertising with the socially optimal level.[11] Lewis and Sappington (1994) model quality signals that inform consumers of their match with the product. They examine how a producer chooses the precision of such signals and find that he often chooses the best available signal or the completely uninformative signal. The monopolist in their model, however, does not have private information. Anderson and Renault (2006a) show that a monopolist would reveal only partial information regarding consumers' match with his product. They assume that consumers perfectly learn their match once they incur the search cost to visit the store. I assume that information on product attributes is hard to obtain unless the seller chooses disclosure, as is the case with nutrient profile of food and service quality of HMOs.

The outline of the paper is the following. Section 2 introduces the model and examines the complete-information benchmark. Section 3 examines products with known vertical quality and unknown horizontal attribute. Section 4 examines products with unknown vertical quality and horizontal attribute. Section 6 concludes. All proofs are in the appendix.

2 A Benchmark Model: Complete Information

A profit-maximizing monopolist sells a product to many consumers. For simplicity, I assume that there is no production cost. The product is characterized by its vertical quality and horizontal attribute. For brevity, I refer to the vertical quality as "quality," and the horizontal attribute as "location" hereafter. Both quality and location of the product are exogenously determined, which can be interpreted in two ways. First, the situation considered here represents a disclosure subgame in which quality and location are chosen in an earlier stage of an extended game. Second, quality and location are

[10] See Bagwell (2005) for a comprehensive review of the advertising literature.

[11] Examples include Grossman and Shapiro (1984) and Meurer and Stahl (1994).

results of an R&D process which involves experiments with random outcomes.

Denote quality by v and location by l. The monopolist's product is characterized by vector (v, l). I assume that $v \geq 0$ and $0 \leq l \leq 1$. The monopolist learns (v, l) immediately after they are realized. For example, he can learn (v, l) by surveying a small group of consumers.

Utility-maximizing consumers of mass one are uniformly distributed on $[0, 1]$. If a consumer located at c purchases one unit of the product from monopolist (v, l) at a price p, her utility is,

$$U(c; p; v, l) \equiv v - |c - l| - p. \tag{1}$$

That is, a consumer's utility is the product's quality less its price and her mismatch, defined as the distance between the consumer and the product. If a consumer does not buy the product, her utility is zero regardless of her location. Consumer c buys one unit of the product if $U(c; p; v, l) \geq 0$.

In the complete-information benchmark, vector (v, l) is common knowledge. There is no uncertainty in the game. The monopolist chooses a price, and then each consumer decides whether to buy a unit of the product.

Proposition 1. *Suppose the product's quality and location (v, l) are common knowledge. In the Subgame Perfect Equilibrium (SPE), the monopolist's profit and demand both increase in v and decrease in $|l - 0.5|$. Equilibrium price increases in v and is not monotonic in $|l - 0.5|$.*

Intuitively, the product becomes more popular when location approaches .5. The monopolist can take advantage of the increased popularity, sell more units of the product, and make a higher profit. When vertical quality increases, and the monopolist can take advantage of the increased willingness to pay to increase both price and demand, and hence the profit.

The pattern of price with respect to location is more complicated. If $0 \leq v < \frac{3}{2}$, the equilibrium price first increases and then decreases as location approaches .5. If $v \geq \frac{3}{2}$, the equilibrium price always increases as location approaches .5. In general, price has to be low when location is close to 0 or 1, since otherwise the monopolist barely gets any demand.

As location moves away from 0 or 1 toward .5, more consumers become interested in the product and the monopolist raises equilibrium price. When location gets close to .5, two possibilities arise. If quality is high, the monopolist sells to all consumers by making the consumer with the worst match indifferent. He hence increases the equilibrium price as location approaches .5. If quality is low, he does not try to sell to all consumers as the price would be too low. The closer is the product's location to .5, the more units he tries to sell. In order to sell more, he lowers the equilibrium price as location approaches .5.

FIGURE 1
EQUILIBRIUM PRICE, DEMAND AND PROFIT UNDER COMPLETE INFORMATION

$v < 1$ in this figure. The x-axis represents the product's horizontal attribute space $[0, 1]$. The thin solid line is the monopolist's equilibrium price, the dashed line equilibrium demand, and the thickened solid line equilibrium profit. The price and demand curves overlap when location is close to 0 or 1.

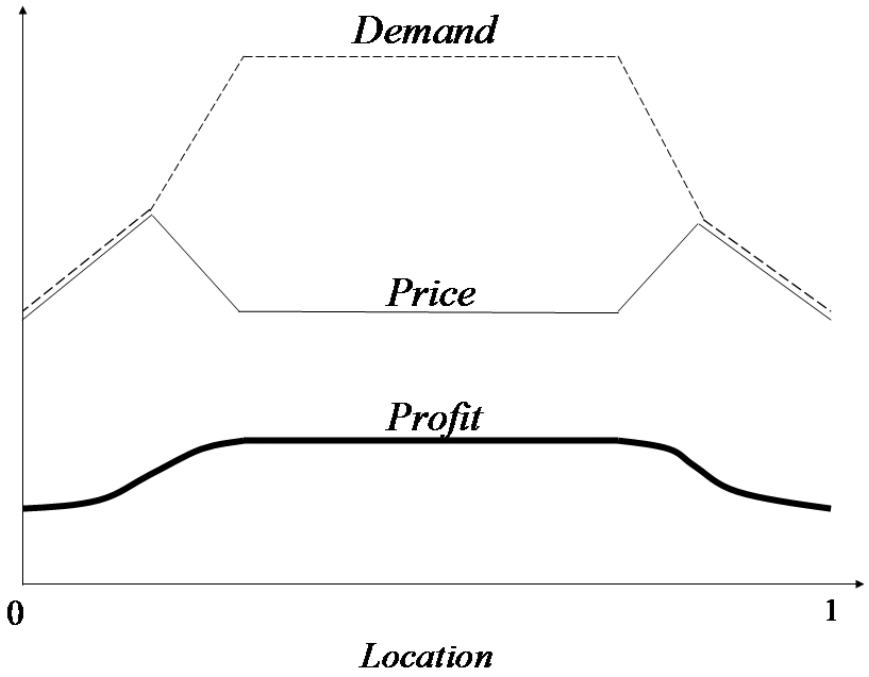


Figure 1 illustrates the low quality case: it shows how the equilibrium price, demand and profit change with the product's location when quality is fixed to be lower than 1. The monopolist in equilibrium never sells to the entire market. As explained, equilibrium price first increases and then decreases as location approaches .5, while equilibrium demand and profit both increase.

3 Known Quality, Unknown Horizontal Attribute

In this section, consumers know the product's quality, but not its location. The monopolist has the option to disclose his product's location at no cost. The scenario best describes mature products that have accumulated some quality reputation. For example, when a consumer decides whether to buy a popular digital camera, she can learn its quality reputation by reading online reviews or asking her friends. However, she can hardly find out her exact match without trying the camera. To be more specific, I assume product quality $v \geq 0$ to be common knowledge. The extensive form is as follows.

Stage 1 Nature determines l according to the probability density function $g(l)$. The monopolist knows l; consumers know their own locations and $g(l)$, but not l.

Stage 2 The monopolist decides whether to disclose his location.

Stage 3 The monopolist chooses a price. Consumers decide whether to buy the product.

I focus on Perfect Bayesian Equilibria (PBE) in pure strategies and categorize them into two groups. A Fully Revealing Equilibrium is a PBE in which the monopolist always chooses disclosure. Any other PBE is a Partially Revealing Equilibrium.

Proposition 2. *A Fully Revealing Equilibrium always exists.*

A Fully Revealing Equilibrium is supported by an extreme off-equilibrium-path belief: consumers believe that the product is located at 0 whenever the monopolist chooses nondisclosure. In a Fully Revealing Equilibrium, the monopolist at every location charges the complete-information equilibrium price and earns the corresponding profit.

In the remaining of this section, I discuss Partially Revealing Equilibria and show that the monopolist in such equilibria discloses his location only when it is in a central region. Moreover, the region is symmetric around .5 and it shrinks as quality increases.

Consider any Partially Revealing Equilibrium. The monopolist's equilibrium profit is higher at every location in a Partially Revealing Equilibrium than in a Fully Revealing Equilibrium, as the monopolist can always earn the complete-information equilibrium profit by choosing disclosure. If the monopolist earns the same profit whether he chooses

disclosure or not, I assume that the monopolist chooses nondisclosure. The tie-breaking rule is adopted from Anderson and Renault (2006b) and motivated by the reality that there may be positive disclosure costs.

When the monopolist chooses nondisclosure, consumers may infer the product's location from the equilibrium price. For any equilibrium price p, let $L(p)$ be the set of locations at which the monopolist chooses nondisclosure and charges p. The consumer located at c, upon observing price p, expects her utility to be

$$EU(c; p; v, l) = v - p - E(|c - l||l \in L(p)). \tag{2}$$

The last term, $E(|c - l||l \in L(p))$, is her expected mismatch with the product. She buys one unit of the product if $EU(c; p; v, l) \geq 0$.

Let $D^p(p; v, l)$ denote the equilibrium demand of firm[12] (v, l) when it chooses nondisclosure and charges equilibrium price p.

$$D^p(p; v, l) = m(\{c|EU(c; p; v, l) \geq 0\}). \tag{3}$$

The right-hand side is the measure of the set of consumers who expect positive utility from buying the product. The firm's corresponding equilibrium profit is

$$\pi^p(p; v, l) = p \cdot D^p(p; v, l) = p \cdot m(\{c|EU(c; p; v, l) \geq 0\}). \tag{4}$$

Firms with $l \in L(p)$ make the same equilibrium profit by (2)-(4). Therefore, if two nondisclosing firms make different levels of equilibrium profit, they must charge different equilibrium prices. However, there is no cost for the low profit firm to mimic the high profit one by charging the latter's equilibrium price. Consequently, I have lemma 1.

Lemma 1. *All nondisclosing firms make the same profit in a Partially Revealing Equilibrium.*

[12] A firm refers to a type of the monopolist.

Lemma 1 suggests that although nondisclosing firms can charge different equilibrium prices, they must make the same equilibrium profit. Denote this profit by π^p, the following lemma compares π^p with complete information equilibrium profit levels.

Lemma 2. *In a Partially Revealing Equilibrium,* $\pi^c(v,0) = \pi^c(v,1) \leq \pi^p \leq \pi^c(v,0.5)$.

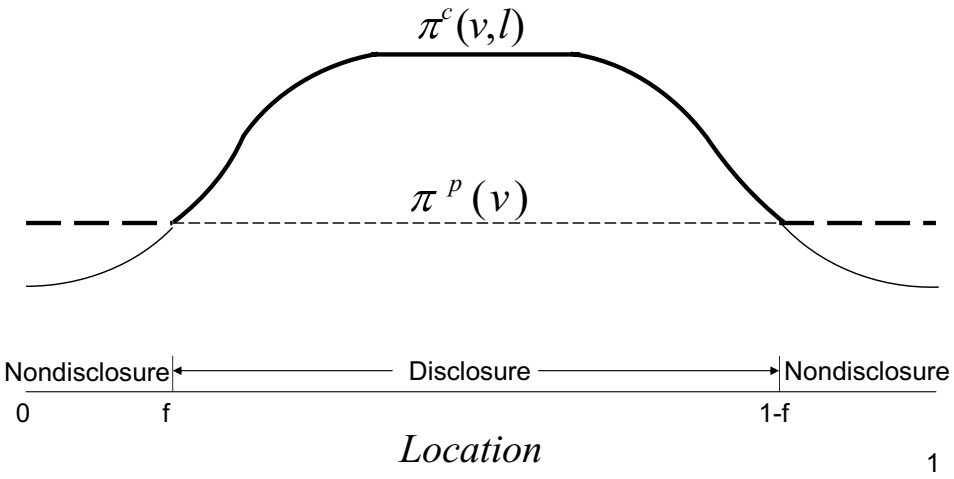
Lemma 2 states that a nondisclosing firm makes more profit than when he is known to be located at 0 or 1 and less profit than when he is known to be located at .5. In other words, he makes the same equilibrium profit as some firm does under complete information, which leads to the following proposition.

Proposition 3. *In every Partially Revealing Equilibrium, there exists a threshold* f *with* $0 \leq f \leq 0.5$ *such that the monopolist discloses his location if and only if* $f < l < 1 - f$. *Equilibrium profit is* $\pi^c(v,l)$ *when he chooses disclosure, and* $\pi^c(v,f)$ *otherwise.*

See Figure 2 below for an illustration of Proposition 3.

FIGURE 2
PROFIT IN A PARTIALLY REVEALING EQUILIBRIUM

In this figure, $0 < f < 0.5$. The solid curve is the monopolist's profit under complete information, $\pi^c(v,l)$. The dashed straight line is π^p. The thickened parts of the two lines represent the monopolist's profit in the Partially Revealing Equilibrium.



As shown in Figure 2, f is determined by $\pi^c(v,f) = \pi^p$. The monopolist discloses his location in a central region: $(f, 1-f)$. It is natural that firms located closer to .5 are

more likely to choose disclosure as their complete-information profit is higher. However, why don't all firms choose disclosure as the unraveling result predicts? In particular, why are firms located at f and $1-f$ willing to pool with more "unpopular" firms?

The intuition is as follows. Consumers learn that the product is not located in the central region upon seeing nondisclosure. However, they do not know whether the product is on the "left" or "right" side of the product space. On average, they are more optimistic about their match compared with under disclosure. As a result, the monopolist keeps the product's location ambiguous when it is close enough to 0 or 1.

Figure 2 points to the possibility of ranking different equilibria in terms of the monopolist's equilibrium profit: for an equilibrium with higher f, more firms chose nondisclosure and their equilibrium profit π^p is higher. I formalize this result for further use.

Corollary 1. *Consider Partially Revealing Equilibria A with threshold f_A and B with threshold f_B. If $f_A > f_B$, equilibrium profit is higher at every location in A than in B.*

Next, I discuss the existence of a Partially Revealing Equilibrium. The following off-equilibrium-path belief can support any possible Partially Revealing Equilibrium. When a firm deviates to nondisclosure and an off-equilibrium-path price, every consumer believes that he is located at 0. Under this belief, no firm benefits from charging an off-equilibrium-path price. Moreover, no firm benefits from changing its disclosure strategy.

The following proposition offers a sufficient condition for the existence of a Partially Revealing Equilibrium. A *Non-Revealing Equilibrium* in the proposition refers to a Partially Revealing Equilibrium in which no firm chooses disclosure.

Assumption S. *$g(l) = g(1-l)$ for any $l \in [0,1]$, and $g(0) > 0$.*

Proposition 4. *Suppose Assume S holds. A Partially Revealing Equilibrium in which all nondisclosing firms charge the same price exists if $v > 2 - \sqrt{2}$. A Non-Revealing Equilibrium exists if $v \geq 1$.*

Assumption S requires locations to be symmetrically distributed around .5 and the firm is located at 0 with a strictly positive probability. Under this assumption, the proposition suggests that the existence of a Partially Revealing Equilibrium relies on the quality being

sufficiently high. If quality is low, the monopolist can hardly get any demand unless he attracts nearby consumers by disclosure. If quality is high, consumers may still purchase the product when the monopolist chooses nondisclosure. This intuition suggest that the product's quality relates to the likelihood of disclosure. The next proposition formalizes the relationship by focusing on a particular equilibrium.

Definition 1. *The* **Highest Profit Symmetric Equilibrium (HPSE)** *is the Partially Revealing Equilibrium in which (1) for any equilibrium price p charged by some nondisclosing firms, $l \in L(p)$ implies $1 - l \in L(p)$, and (2) the equilibrium profit for every firm is the highest among all Partially Revealing Equilibria that satisfy (1).*

In a symmetric equilibrium, the monopolist has to charge the same equilibrium price for locations with the same distance from .5. The HPSE is the symmetric equilibrium with the highest equilibrium profit at every location. By Corollary 1, the HPSE is also the symmetric equilibrium with the biggest disclosure threshold and the highest number of disclosing firms. Focusing on the HPSE makes the analysis much more tractable. On the other hand, consumers would also expect the monopolist to arrive at such an equilibrium.

Proposition 5. *Suppose Assumption S holds. When v increases, disclosure threshold in the HPSE increases.*

Proposition 5 indicates that the higher is the product's quality, the *less* likely the monopolist chooses disclosure. To the monopolist, disclosure always has the benefit of attracting consumers nearby at the cost of deterring consumers far away. When quality is low, the benefit is crucial and it outweighs the cost. As quality becomes higher, consumers are more likely to buy the product without disclosure. When quality is high enough, the monopolist tries to cover the entire market at a high price. Disclosure in this case would lower marginal consumers' willingness to pay: the cost of disclosure starts to outweigh its benefit.

Some evidence from the magazine market provides support for Proposition 5. Among the 100 best-selling magazines on Amazon.com as of November 9, 2006, 49 (49%) offer free trials through electronic pages or paper issues. Out of the 100 magazines, 13 won the

National Magazine Award in General Excellence during 2000-2006. Among the 13 magazines, only 4 (31%) offer free trials.[13] That is, the percentage of award-winning magazines that offer free trials is lower than that of general top selling magazines. Furthermore, the more recently a magazine won the award, the less likely it offers free trials. See Table 1 below for a more detailed comparison of the trial-offering behavior.

TABLE 1 Decisions of award-winning magazines to offer free trials

	No. of Mags	No. of Mags with Trials	% of Mags with Trials
Amazon.com	100	49	49
2000-2006 Award	13	4	31
2001-2006 Award	11	3	27
2003-2006 Award	9	2	22
2005-2006 Award	6	1	17

Free trials would disclose the magazine's horizontal attributes such as the text-graphics ratio. Under the interpretation that the award signals strong quality reputation among consumers, Proposition 5 is consistent with the fact that award-winning magazines are less likely to offer free trials. Under the assumption that a more recent award may carry more weight in consumers' quality evaluation, the proposition is also consistent with the fact that the more recent the award is, the less likely the magazine offers free trials.[14]

The wine market offers another example. Bordeaux winemakers started to list grape varieties on the wines' labels in spring 2006. O'Connell (2006), in the *Wall Street Journal*, points out that this change reflects an emerging eagerness for French wine producers to reach out to Americans, who are drinking fewer bottles from France. Yvon Mau, a Bordeaux wine specialist, added varietal information to newly released wines under

[13]Award is given by the American Society of Magazine Editors. The General Excellence category recognizes overall excellence in magazines. Other prestigious awards such as the Investigative Reporters and Editors Award and the Pulitzer Prize often focus on individual articles rather than the overall quality of the magazines. Award winners (2000-2006) are: Wired, Time, Popular Science*, National Geographic, Newsweek, Esquire, Gourmet, Entertainment Weekly*, National Geographic Adventure, Magazine, Dwell*, Saveur*. Magazines with * offer free trials.

[14]Past winners are eligible for the same award. For instance, National Geographic has won the General Excellence award four times since 1984.

its key brand Premius, but only for bottles sold in English-speaking countries. Under the assumption that Bordeaux wines' reputation is stronger in French-speaking countries than in America and other English-speaking countries, the observations are consistent with Proposition 5.

To finish the section, I consider a social planner who aims to maximize consumer welfare by using mandatory disclosure policies. The following example shows that mandating disclosure in the HPSE may hurt both consumer welfare and the monopolist's profit.

Example 1. *Suppose* $v = 1$ *and* l *equals* a *and* $1-a$ *with probability .5 each, with* $0 \leq a < 0.5$. *In the HPSE, the monopolist never chooses disclosure. Mandating disclosure reduces expected consumer welfare when* $3 - 2\sqrt{2} < a < 0.5$ *and increases expected consumer welfare otherwise.*

Mandating disclosure forces the monopolist into the complete-information benchmark and hence always lowers his equilibrium profit. Compared with this benchmark, price in the HPSE is lower, demand is higher and it is possible that more consumers derive a positive surplus. On the other hand, mandating disclosure can protect consumers from regretting their purchase. When a is close to 0 in this example, the second effect is crucial and consumers prefer disclosure to be mandated. When a is close to .5, consumers have less uncertainty in matching with the product. They would rather pay a lower price in the HPSE and enjoy a higher consumer surplus.

4 Unknown Quality, Unknown Horizontal Attribute

In the real world, consumers may not know anything about the product. Many new products come into the market every day and firms upgrade old products all the time. For new or upgraded products, sellers often have to disclose all product information if any. For example, consumers would learn almost all aspects of the product once the seller offers free trials or publish consumer reviews of the product. Given that it is hard to separately disclose quality and location, when does the monopolist choose his disclosure strategy? I try to answer this question by analyzing the following game.

Stage 1 Nature determines the value of v and l with $v \geq 0$ and $0 \leq l \leq 1$. The monopolist knows both v and l. Consumers know their own locations and distributions of v and l, but they do not know v or l.

Stage 2 The monopolist decides whether to choose disclosure. If he does, every consumer learns both v and l.

Stage 3 The monopolist chooses a price. Consumers decide whether to buy the product.

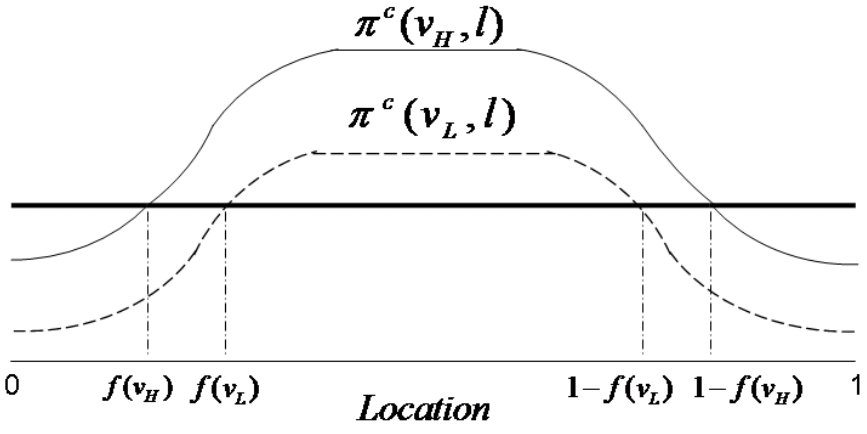
A Fully Revealing Equilibrium in which the monopolist always chooses disclosure still always exists. It can be supported by the following off-equilibrium-path belief: whenever a firm deviates to nondisclosure, consumers believe that its product has quality zero. A similar off-equilibrium-path belief supports any possible Partially Revealing Equilibrium. If a firm deviates to nondisclosure and an off-equilibrium-path price, consumers believe that the product has quality zero. The following proposition discusses the monopolist's disclosure behavior in the Partially Revealing Equilibria.

Proposition 6. *In every Partially Revealing Equilibrium, there exists a decreasing function $f(v)$ such that the monopolist chooses disclosure if and only if $l \in (f(v), 1 - f(v))$.*

Figure 3 below illustrates this proposition.

FIGURE 3
EQUILIBRIUM PROFIT WITH UNKNOWN QUALITY AND LOCATION

$0 \leq v_L < v_H$ and $0 < f(v_H) < f(v_L) < 0.5$. The solid curve is the complete-information equilibrium profit for quality v_H, and the dashed curve for quality v_L. The thickened straight line is the monopolist's profit when he chooses nondisclosure in equilibrium.



As shown in Figure 3, the monopolist chooses disclosure when location is in a central region. The region now enlarges as quality becomes higher, which reflects the monopolist's new incentive to reveal a high quality. The result implies that a higher quality firm is more likely to choose disclosure when his product is new. Nevertheless, the following example shows that the monopolist may choose nondisclosure even when his product has the highest possible level of quality.

Example 2. *v and l are independent random variables. Quality v equals v_H or v_L with probability .5 each, where $0 \leq v_L < v_H$. Location l equals 0 or 1 with probability .5 each. There exists a Non-Revealing Equilibrium when (1) $0 \leq v_H < 2$ and $v_L \geq \frac{v_H^2}{2} - v_H + 1$, or (2) $v_H \geq 2$ and $v_L \geq v_H - 1$.*

In this example, the monopolist with quality v_H chooses nondisclosure when the difference of v_L and v_H is small. In general, when the distribution of quality is more widely dispersed, high quality firms have a stronger incentive to choose disclosure.

The results in this section provide possible explanations for firms' nondisclosure behavior in Mathios (2000) and Jin (2005). First, the higher is the average quality, the more likely the firm discloses the quality profile. Second, a firm is more likely to choose disclosure when its quality profile is well balanced across different quality dimensions. Third, disclosing firms do not necessarily have higher average quality than nondisclosing firms. It may be the case that a disclosing firm has lower average quality, but a more balanced quality profile, than a nondisclosing firm. Last, more firms choose disclosure when quality dispersion is large.

5 Concluding Remarks

In essence, introducing an unknown location breaks down unraveling. In both information scenarios above, the Partially Revealing Equilibria arise from the monopolist's incentive to hide an unfavorable attribute. In another possible scenario, consumers know the location of the product but not the vertical quality. The model then is the same as in Grossman

(1981) and Milgrom (1981). The monopolist would always choose disclosure as in the standard argument of unraveling, as in Jin and Leslie (2003).

Finally, I discuss some assumptions and marketing implications.

5.1 Positive Costs

I have assumed that production cost is zero. A more general cost structure can be incorporated. For example, suppose the fixed and marginal cost both increase in product quality. The monopolist's profit under complete information would still increase as the product's location approaches .5. As a result, Proposition 3 would hold. Proposition 4 would hold with modified thresholds. As long as marginal cost increases slowly enough in the product's quality, complete-information equilibrium profit increases in product quality and Proposition 6 holds.

I have also assumed that disclosure cost is zero. This can be relaxed as well. As long as disclosure cost is low and does not change with the product's location, Proposition 3 still holds. Proposition 4 holds with modified thresholds. Proposition 6, however, need not hold when disclosure cost increases in the product's vertical quality.

5.2 Disclosure Dynamics

One can learn some disclosure dynamics by linking the two different information scenarios studied in this paper. In the product's early age, it has no quality reputation. Results from Section 4 suggest that the higher the product's quality is, the more likely the monopolist chooses disclosure. Once the product has become familiar to consumers and earned some quality reputation, results from Section 3 suggest that the higher the product's quality is, the less likely the monopolist chooses disclosure.

As a result, a high quality monopolist may choose disclosure in the beginning but not afterwards. He earns more profit later by exploiting his reputation of high quality. On the other hand, a low quality monopolist may choose nondisclosure in the beginning but switch to disclosure afterwards. He earns more in the beginning by not revealing the true quality of his product.

APPENDIX

Proof of Proposition 1. For each possible (v, l), the monopolist chooses a price to maximize his profit. Firm (v, l) has the same equilibrium strategies as firm $(v, 1-l)$, for any possible location l. Hence I examine only firms with $l \in [0, \frac{1}{2}]$. When a firm charges price p and is located at $l \in [0, \frac{1}{2}]$, its profit is

$$\pi^c(p; v, l) = \begin{cases} p, & \text{if } 0 \leq p < v - (1-l) \\ p(l+v-p), & \text{if } v-(1-l) \leq p < v-l \\ 2(v-p)p, & \text{if } v-l \leq p < v \\ 0, & \text{if } p > v \end{cases}$$

When $0 \leq v < \frac{3}{2}$, there are three possible cases.

- If $\frac{v}{2} \leq l \leq \frac{1}{2}$, which is possible only when $0 \leq v \leq 1$, the profit is maximized at $p = \frac{v}{2}$, the corresponding demand is v, and the maximum profit is $\frac{v^2}{2}$.
- If $\frac{v}{3} \leq l < \frac{v}{2}$, the profit is maximized at $p = v - l$, the corresponding demand is $2l$, and the maximum profit is $2l(v-l)$.
- If $0 \leq l \leq \frac{v}{3}$, the profit is maximized at $p = \frac{v+l}{2}$, the corresponding demand is $\frac{v+l}{2}$, and the maximal profit is $\frac{(v+l)^2}{4}$.

When $v \geq \frac{3}{2}$, there are two cases.

- If $2 - v \leq l \leq \frac{1}{2}$, the profit is maximized at $p = v + l - 1$, the corresponding demand is 1, and the maximum profit is $v + l - 1$.
- If $0 \leq l < 2 - v$, which is possible only when $v < 2$, the profit is maximized at $p = \frac{v+l}{2}$, the corresponding demand is $\frac{v+l}{2}$, and the maximal profit is $\frac{(v+l)^2}{4}$. □

Proof of Lemma 1. If Lemma 1 is false, there must exist two distinct locations $l_A, l_B \in [0, 1]$ such that in a Partially Revealing Equilibrium (F1) the monopolist chooses nondisclosure at l_A and l_B, and (F2) he earns a higher profit at l_A than at l_B. Given (F1), if the monopolist charges the same equilibrium price at l_A and l_B, he obtains the same

equilibrium demand at l_A and l_B by equation (2) and (3). By equation (4), he makes the same equilibrium profit at l_A and l_B, which contradicts (F2). Therefore, the monopolist must charge different equilibrium prices at l_A and l_B.

If the nondisclosing firm l_B deviates to charge firm l_A's equilibrium price, he gets firm l_A's equilibrium demand by equation (2) and (3), and hence gets firm l_A's equilibrium profit by equation (4). By (F2), firm l_B makes a higher profit in this deviation, a contradiction. □

Proof of Lemma 2. By definition of a Partially Revealing Equilibrium, there exists a nondisclosing firm (v, l). For this firm,

$$\pi^c(v, 0) = \pi^c(v, 1) \leq \pi^c(v, l) \leq \pi^p,$$

where the first two (in)equalities are from Proposition 1.

I now show $\pi^p \leq \pi^c(v, \frac{1}{2})$. Consider any equilibrium price p charged by some nondisclosing firm. For any given $c \in [0, 1]$, by Jensen's inequality,

$$|c - E(l|l \in L(p))| \leq E(|c - l||l \in L(p)).$$

Therefore, for any given $c \in [0, 1]$,

$$\begin{aligned} EU(c; p; v, l) &= v - p - E(|c - l||l \in L(p)) \\ &\leq v - p - |c - E(l|l \in L(p))| \\ &= U(c; p; v, E(l|l \in L(p))). \end{aligned} \tag{5}$$

As a result,

$$\begin{aligned} \pi^p &= p \cdot D^p(p; v, l) \\ &= p \cdot m(\{c|EU(c; p; v, l) \geq 0\}) \\ &\leq p \cdot m(\{c|U(c; p; v, E(l|l \in L(p))) \geq 0\}) \\ &= p \cdot D^c(p; v, E(l|l \in L(p))) \end{aligned} \tag{6}$$

$$
\begin{aligned}
&\leq \pi^c(v, E(l|l \in E(p))) \\
&\leq \pi^c(v, \frac{1}{2}),
\end{aligned}
$$

where the third line is from inequality (5), and the sixth from Proposition 1. □

Proof of Proposition 3. In a Partially Revealing Equilibrium, all nondisclosing firms earn π^p by Lemma 1. Let

$$L = \{l|g(l) > 0 \; and \; \pi^c(v, l) \leq \pi^p\}.$$

By definition, $L \neq \emptyset$. Suppose $l \in L$ and $g(l') > 0$. If $|l' - \frac{1}{2}| \geq |l - \frac{1}{2}|$, then $\pi^c(v, l') \leq \pi^c(v, l)$ by Proposition 1, and hence $l' \in L$. By Lemma 2, there exists a location $f \in [0, \frac{1}{2}]$ such that $\pi^c(v, f) = \pi^p$ and $L = [0, f] \cup [1 - f, 1]$. □

Proof of Corollary 1. Disclosing firms make their complete-information profit in both A and B. By Proposition 3, nondisclosing firms earn $\pi^c(v, f_A)$ in equilibrium A and $\pi^c(v, f_B)$ in equilibrium B. By Proposition 1, $\pi^c(v, f_B) \leq \pi^c(v, f_A)$. □

Proof of Proposition 4. When $1 > v \geq 2 - \sqrt{2}$,

$$\pi^c(v, 0) = \frac{v^2}{4} \leq v - \frac{1}{2} < \frac{v^2}{2} = \pi^c(v, \frac{1}{2}).$$

Therefore, there exists $f \in [0, \frac{1}{2}]$ such that

$$v - \frac{1}{2} = \pi^c(v, f).$$

Suppose all firms located in $[0, f]$ or $[1-f, 1]$ charge the same price. Since $g(0) = g(1) > 0$, there exist at least two such firms.

The two consumers located at 0 and 1 expect the highest mismatch, .5. To see this, realize two facts. First, they expect a mismatch of .5. Recall that L is the set of locations where the monopolist chooses nondisclosure.

$$E(|0 - l||l \in L) = E(|1 - l||l \in L) = E(l|l \in L) = \frac{1}{2}.$$

Second, they have the highest expected mismatch. Let $0 \leq c_1 < c_2 \leq \frac{1}{2}$,

$$\begin{aligned}
&E(|c_2 - l||l \in L) - E(|c_1 - l||l \in L) \\
&\leq \ (c_2 - c_1) \cdot \Pr(l \in [0, c_2)|l \in L) - (c_2 - c_1) \cdot \Pr(l \in [c_2, f] \cup [1 - f, 1]|l \in L) \\
&= \ (c_2 - c_1) \cdot (\Pr(l \in [0, c_2)|l \in L) - \Pr(l \in [c_2, f] \cup [1 - f, 1]|l \in L)) \\
&\leq \ 0.
\end{aligned}$$

As a result, every consumer buys the product when the monopolist chooses nondisclosure and charges $p = v - \frac{1}{2}$. Nondisclosing firms earns $\pi^p = v - \frac{1}{2}$ and a Partially Revealing Equilibrium with disclosure threshold f exists.

Now consider $v \geq 1$. From Proposition 1, $\pi^c(v, \frac{1}{2}) = v - \frac{1}{2}$. If every firm chooses nondisclosure and charges $p = v - \frac{1}{2}$. Every consumer buys the product and the monopolist's profit is $v - \frac{1}{2} = \pi^c(v, \frac{1}{2})$. A Non-Revealing Equilibrium hence exists. □

Proof of Proposition 5. If $v \geq 1$, $f = \frac{1}{2}$ in the HPSE by Proposition 4. Consider $v < 1$. Denote the HPSE profit of nondisclosing firms by $\pi^p_H(v)$ when quality is v. By Proposition 3, $\pi^p_H(v) = \pi^c(v, f)$, where f is the disclosure threshold in the HPSE for quality v. Let $\Delta v > 0$ be an infinitesimal increase in quality and f' the disclosure threshold in the HPSE when quality is $v + \Delta v$. I show that $f' \geq f$ by proving two claims.

Claim 1.

$$D^c(v, f) \leq D^p_H(p; v, l),$$

where the right-hand side is the HPSE demand of any firm (v, l) that chooses nondisclosure and charges price p.

Since

$$p \cdot D^p_H(p; v, l) = p^c(v, f) \cdot D^c(v, f),$$

it is sufficient to show $p \leq p^c(v, f)$. Consider three cases. First, $f = \frac{1}{2}$, which means that all firms in the HPSE choose nondisclosure. Suppose firm (v, l) charges $p' > p^c(v, f) = \frac{v}{2}$ in the HPSE,

$$p' \cdot D^p_H(p'; v, l) \leq p' \cdot D^c(p'; v, l) < \pi^c(v, \frac{1}{2}).$$

The first inequality is from (6). Firm (v, l) hence chooses disclosure, a contradiction.

Second, $f \in [\frac{v}{3}, \frac{v}{2}]$. Suppose a nondisclosing firm (v, l) charges $p' > p^c(v, f)$ in the HPSE,

$$\begin{aligned} p' \cdot D^p(p'; v, l) &\leq p' \cdot D^c(p'; v, E(l|l \in L(p'))) \\ &= p' \cdot D^c(p'; v, \frac{1}{2}) = p' \cdot D^c(p'; v, f) < \pi^c(v, f). \end{aligned}$$

The first line is from (6), the first equality in the second line is from (1) in the definition of HPSE, and the rest are from Proposition 1. Firm (v, f) hence chooses disclosure. Therefore, no firm charges p' and chooses nondisclosure in the HPSE.

Third, $f \in [0, \frac{v}{3})$. Suppose some firms charge price $p' > p^c(v, f)$ and choose nondisclosure in the HPSE. The consumer located at c has an expected mismatch of

$$E(|c-l||l \in L(p')) \begin{cases} \geq |c - E(l|l \in L(p'))| = |c - \frac{1}{2}| \geq \frac{1}{2} - f, & \text{if } c \notin (f, 1-f) \\ = \int_0^f \Pr(l|l \in L(p'))(c - l + 1 - l - c)dl \geq \frac{1}{2} - f, & \text{if } c \in (f, 1-f) \end{cases}$$

where the second line is from $\int_0^f l \Pr(l|l \in L(p'))dl \leq f \int_0^f \Pr(l|l \in L(p'))dl = \frac{1}{2}f$.

Therefore, every consumer's expected mismatch is greater than $\frac{1}{2} - f$. As firm (v, l) charges p' in the HPSE and gets a positive demand, $v - p' \geq \frac{1}{2} - f$. Since $f \in [\frac{v}{3}, \frac{v}{2}]$, $v - p^c(v, f) = \frac{1}{2}(v - f) > v - p'$ by Proposition 1. As a result, $\frac{1}{2}(v - f) > \frac{1}{2} - f$. When $v \leq \frac{3}{4}$, I reach a contradiction as

$$\frac{1}{2}(v - f) - (\frac{1}{2} - f) \leq \frac{1}{2}(v + \frac{v}{3} - 1) \leq 0.$$

When $\frac{3}{4} < v < 1$,

$$\pi^c(v, \frac{v}{3}) \leq v - \frac{1}{2} < \frac{v^2}{2} = \pi^c(v, \frac{1}{2}).$$

There exists $f^* \in [\frac{v}{3}, \frac{1}{2}]$ with $v - \frac{1}{2} = \pi^c(v, f^*)$. Therefore, there is a Partially Revealing Equilibrium with threshold $f^* > f$, in which all nondisclosing firms charge price $v - \frac{1}{2}$. Thus I also reach a contradiction.

Claim 2.

$$\pi_H^p(v) + \Delta v \cdot D_H^p(p; v, l) \leq \pi_H^p(v + \Delta v),$$

where the right-hand side is the profit of nondisclosing firms in the HPSE for quality $v + \Delta v$.

Realize that

$$\begin{aligned}
\pi^c(v + \Delta v, f) &= \pi^c(v, f) + \Delta v \cdot D^c(v, f) \\
&\leq (p + \Delta v) \cdot D_H^p(p; v, l) \\
&= \pi_H^p(v) + \Delta v \cdot D_H^p(p; v, l) \qquad (7) \\
&\leq (p + \Delta v) \cdot D^c(p + \Delta v; v + \Delta v, \frac{1}{2}) \\
&\leq \pi^c(v + \Delta v, \frac{1}{2}), \qquad (8)
\end{aligned}$$

where the first and the last last line are from Proposition 1, the second from Claim 1, and the fourth from (6). Given (7) and (8), there exists $f^* \geq f$ such that

$$\pi_H^p(v) + \Delta v \cdot D_H^p(p; v, l) = \pi^c(v + \Delta v, f^*).$$

By (2) in the definition of HPSE, Claim 2 is true if there exists a symmetric Partially Revealing Equilibrium with threshold f^* when quality is $v + \Delta v$. Such an equilibrium obviously exists if $f^* = f$.

Consider $f^* > f$. Denote by p_f the equilibrium price of firm (v, l) in the HPSE when quality is v. In the same equilibrium, denote by $L(p_f)$ the set of locations at which the monopolist chooses nondisclosure and charges p_f. Let $L^* = (f, f^*] \cup [1 - f^*, 1 - f) \cup L(p_f)$. By (1) in the definition of HPSE,

$$|c - l| + |c - (1 - l)| \leq |c - l'| + |c - (1 - l')|, \forall l \in L^*, \forall l' \in L(p_f), \forall c \in [0, 1],$$

and the inequality is strict for some c. As a result,

$$m(\{c | v - p_f - E(|c - l| | l \in L^*) \geq 0\}) \geq m(\{c | v - p_f - E(|c - l| | l \in L(p_f)) \geq 0\}), \quad (9)$$

and the equality holds only if both sides equal 1.

When both quality v and price p_f increase by Δv, there exists a price p^* such that

$$p^* \cdot m(\{c|v + \Delta v - p^* - E(|c - l||l \in L^*) \geq 0\}) = (p + \Delta v) \cdot D_H^p(p; v, f). \qquad (10)$$

If $p^* \neq p + \Delta v$ for any equilibrium price p charged by some nondisclosing firm in the HPSE when quality is v, a symmetric Partially Revealing Equilibrium with threshold f^* exists. In this equilibrium, nondisclosing firms with $l \in L^*$ charge p^* and other nondisclosing firms charge Δv more than their equilibrium price in the HPSE when quality is v.

If $p^* = p' + \Delta v$ for some equilibrium price p', by (10),

$$m(\{c|v + \Delta v - p^* - E(|c - l||l \in L^*) \geq 0\}) = m(\{c|v - p' - E(|c - l||l \in L(p')) \geq 0\}).$$

Following (9), the equation above holds only if both sides equal 1, which implies $p^* = p' + \Delta v = (p' + \Delta v) \cdot D_H^p(p', v, l)$ and

$$p^* \cdot m(\{c|v - p^* - E(|c - l||l \in (L^* \cup L(p'))) \geq 0\}) = p^*.$$

A symmetric Partially Revealing Equilibrium with threshold f^* exists. In this equilibrium, nondisclosing firms with $l \in L^* \cup L(p')$ charge p^* and other nondisclosing firms charge Δv more than their equilibrium price in the HPSE when quality is v. This ends the proof of Claim 2.

By Claim 1 and 2,

$$\begin{aligned} \pi^c(v + \Delta v, f) &= \pi^c(v, f) + \Delta v \cdot D^c(v, f) \\ &\leq \pi_H^p(v) + \Delta v \cdot D_H^p(p; v, l) \\ &\leq \pi_H^p(v + \Delta v) \\ &= \pi^c(v + \Delta v, f'). \end{aligned}$$

Therefore, $f' \geq f$. □

Proof of Example 1. By Proposition 4, $f = \frac{1}{2}$ in the HPSE when quality $v = 1$. By Lemma 2,

$$\pi_H^p(1) = \pi^c(1, \frac{1}{2}) = \frac{1}{2}. \tag{11}$$

Equilibrium price has to be .5. For any other price p',

$$D_H^p(p'; 1, a) \leq D^c(p'; 1, E(l|l \in \{a, 1-a\})) = D^c(p'; 1, \frac{1}{2}),$$

and

$$\pi_H^p(1) = p' \cdot D_H^p(p'; 1, a) \leq p' \cdot D^c(p'; 1, \frac{1}{2}) < \pi^c(1, \frac{1}{2}) = \frac{1}{2},$$

which contradicts (11). The expected consumer surplus hence is

$$CS^p = \frac{1}{2} - (\frac{1}{2}a^2 + \frac{1}{2}(1-a)^2).$$

If $\frac{1}{3} \leq a < \frac{1}{2}$, consumer surplus under complete information equals a^2, which is strictly smaller than CS^p. If $0 \leq a < \frac{1}{3}$, consumer surplus under complete information equals $\frac{(1+a)^2}{8} - a^2$, which is smaller than CS^p if $3 - 2\sqrt{2} < a < \frac{1}{3}$ and bigger than CS^p if $0 \leq a \leq 3 - 2\sqrt{2}$. □

Proof of Proposition 6. Nondisclosing firms earn the same equilibrium profit by Lemma 1. For any given v, there exists a threshold $f(v) \in [0, 0.5]$ such that firm (v, l) chooses disclosure if and only if $l \in (f(v), 1 - f(v))$, by the same reasoning in the proof of Proposition 3. Suppose $0 \leq v_1 < v_2$, I show $f(v_1) \geq f(v_2)$. If $f(v_1) < f(v_2)$, there exists a location l such that $f(v_1) < l < f(v_2)$. Firm (v_2, l) chooses nondisclosure in equilibrium while firm (v_1, l) chooses disclosure, which implies $\pi^c(l, v_1) \geq \pi^c(l, v_2)$. By Proposition 1, $\pi^c(v_1, l) < \pi^c(v_2, l)$, a contradiction. □

Proof of Example 2. If the two firms with quality v_H choose disclosure, their equilibrium profit is $\frac{1}{4}v_H^2$ if $0 \leq v_H < 2$, and $v_H - 1$ if $v_H \geq 2$. If every firm chooses nondisclosure and charges the same price, consumers expect quality to be $\frac{1}{2}(v_L + v_H)$, and their mis-

match to be .5. When (1) $0 \leq v_H < 2$ and $\frac{1}{4}v_H^2 \leq \frac{1}{2}(v_L + v_H) - \frac{1}{2}$, or (2) $v_H \geq 2$ and $v_H - 1 \leq \frac{1}{2}(v_L + v_H) - \frac{1}{2}$, there exists a Non-Revealing Equilibrium in which every firm charges price $\frac{1}{2}(v_L + v_H) - \frac{1}{2}$. □

References

Anderson, S. and Renault R. "Advertising Content." *American Economic Review*, Vol. 96 (2006a), pp. 93–113.

——— and——— . "Comparative Advertising." Working paper, University of Virginia, 2006b.

Bagwell, K. "The Economics Analysis of Advertising." Mimeo, Department of Economics, Columbia University, 2005.

Bawa, K. and Shoemaker R. "The Effects of Free Sample Promotions on Incremental Brand Sales." *Marketing Science*, Vol. 23 (2004), pp. 345–363.

Becker, G. "A Theory of the Allocation of Time." *Economic Journal*, Vol. 75 (1965), pp. 493–517.

Board, O. "Competition and Disclosure." Working paper, University of Pittsburgh, 2005.

Chong, I. and Kim J. Y. "Costly Information Disclosure in Oligopoly." *The journal of Industrial Economics*, Vol. 52 (2004), pp. 121–132.

Chen, Y. and Xie J. "Third-Party Product Review and Firm Marketing Strategy." *Marketing Science*, Vol. 24 (2005), pp. 218–240.

Crawford, V. and Sobel J. "Strategic Information Transmission." *Econometrica*, Vol. 50 (1982), pp. 1431–1451.

Dye, R. "Proprietary and Nonproprietary Disclosure." *Journal of Business*, Vol. 59 (1986), pp. 331–366.

Dye, R. and Sridhar S. 'Industry-wide Disclosure Dynamics." *Journal of Accounting Research*, Vol. 33 (1995), pp. 157–174.

Farrell, J. "Voluntary Disclosure: Robustness of the Unraveling Result, and Comments on Its Importance." *Antitrust and Regulation*, Lexington Books, 1986, pp. 91-103.

Fishman, M. and Hagerty K. "Mandatory versus Voluntary Disclosure in Markets with

Informed and Uninformed Customers." *Journal of Law, Economics, and Organization*, Vol. 19 (2003), pp. 45–63.

Gorman, W. "A Possible Procedure for Analyzing Quality Differentials in the Egg-Market." *Review of Economics Studies*, Vol. 47 (1980), pp. 843–856.

Grossman, G. and Shapiro C. "Informative Advertising with Differentiated Products." *Review of Economic Studies*, Vol. 51 (1984), pp. 63–81.

Grossman, S. "The Informational Role of Warranties and Private Disclosure about Product Quality." *Journal of Law and Economics*, Vol. 24 (1981), pp. 461–483.

Hotz J. and Xiao M. "Strategic Information Disclosure: The Case of Multi-Attribute Products with Heterogeneous Consumers." Working paper, UCLA, 2007.

Jovanovic, B. "Truthful Disclosure of Information." *Bell Journal of Economics*, Vol. 13 (1982), pp. 36–44.

Jin, G. "Competition and disclosure incentives: an empirical study of HMOs." *RAND Journal of Economics*, Vol. 26 (2005), pp. 93–113.

Jin, G. and Leslie P. "The Effects of Information on Product Quality: Evidence from Restaurant Hygiene Grade Cards." *Quaterly Journal of Economics*, Vol. 118 (2003), pp. 409–451.

Lancaster, J. "A New Approach to Consumer Theory." *Journal of Political Economy*, Vol. 74 (1966), pp. 132–157.

Levin, D., Peck, J. and Ye L. J. 'Quality Disclosure and Competition." Working paper, the Ohio State University, 2005

Lewis, T. and Sappington D. "Supplying Information to Facilitate Price Discrimination." *International Economic Review*, Vol. 35 (1994), pp. 309–327.

Mathios, A. "The Impact of Mandatory Disclosure Regulations on Health Choices: An Analysis of the Salad Dressing Market." *Journal of Law and Economics*, Vol. 43 (2000), pp. 651–678.

Matthews, S. and Postlewaite A. "Quality Testing and Disclosure." *RAND Journal of Economics*, Vol. 16 (1985), pp. 328–340.

Meurer M. and Stahl II D. "Informative Advertising and Product Match." *International Journal of Industrial Organization*, Vol. 12 (1994), pp. 1–19.

Milgrom, P. "Good News and Bad News: Representation Theorems and Applications." *Bell Journal of Economics*, Vol. 12 (1981), pp. 380–391.

MUTH, R., "Household Production and Consumer Demand Functions." *Econometrica*, Vol. 34 (1966), pp. 699–708.

NELSON, P. "Advertising as Information." *Journal of Political Economy*, Vol. 82 (1974), pp. 729–754.

O'CONNELL, V. "Bordeaux Winemakers Reveal What's in the Bottle." *Wall Street Journal, Eastern Edition* April 20, 2006, pp. D.1.

OKUNO-FUJIWAMA, M., POSTLEWAITE A. AND SUZUMURA K. "Strategic Information Revelation." *Review of Economic Studies*, Vol. 57 (1990), pp. 25–47.

ROSEN, S., "Hedonic Prices and Implicit Markets: Product Differentiation in Pure Competition." *Journal of Policital Economy*, Vol. 82 (1974), pp. 34–55.

SEIDMANN, D. AND WINTER E. "Strategic Information Transmission with Verifiable Messages." *Econometrica, Notes and Comments*, Vol. 65 (1997), pp. 163–169.

SHAVELL, S. "Acquisition and Disclosure of Information Prior to Sale." *RAND Journal of Economics*, Vol. 20 (1994), pp. 183–195.

SHIN, H. S. "The Burden of Proof in a Game of Persuasion." *Journal of Economic Theory*, Vol. 64 (1994), pp. 253–264.

STIVERS, A. "Unraveling of Information: Competition and Uncertainty." *The B.E. Journals: Topics in Theoretical Economics*, Vol. 4 (2004).

TIROLE, J. *The Theory of Industrial Organization*, Cambridge: MIT Press, 1994

VERRECCHIA, R. E. "Discretionary Disclosure." *Journal of Accounting and Economics*, Vol. 5 (1983), pp. 179–194.