What Should Consumers Be Told About Product Quality?*

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Abstract

In many markets consumers depend on a quality report by public regulators to guide purchases. Requiring producers to report elements of quality previously unobserved by consumers engages the regulator in an interaction with buyers and sellers. We model this process and let the regulator decide what information to require be reported based on strategic considerations. A product consists of multiple attributes, and requiring a producer to fully report quality in all attributes does not in general lead to an efficient outcome and is not in general the best strategy of the regulator. Even in the absence of any costs of collecting and distributing information, we show that requiring the producer to report on averaged quality in the different attributes may be superior to requiring full reports. We consider how our paper applies to quality reporting in education and health care.

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1 Introduction and Related Literatures

A presumption in public policy is that when consumers have more information about product quality a market functions better. If consumers know more about quality, they would be more likely to choose a product matching their needs. Furthermore, if consumers value and buy on the basis of observable quality, sellers would see a return for investing in quality. Such reasoning is behind the collection and dissemination of more detailed information about the quality of health and education providers (Berwick, 2002; Galvin, 1998; Institute of Medicine, 2001). In probably the most ambitious national effort in health care, the Center for Medicare & Medicaid Services, a federal agency, has released a list of ten separate quality ratings for 17,000 nursing homes, with plans to follow this with ratings for home health agencies, hospitals, and possibly individual doctors.[1] In this paper we challenge the presumption that more information is better, and show that giving consumers only a summary measure may be better than giving them information about many dimensions of quality.

Cost is one reason not to report details. Lancaster (1996) proposed that a consumer product or service be regarded as being composed of a set of attributes, and the complexity of product quality makes it costly to report fully. A new car, for example, has its speed and acceleration, fuel efficiency, and reliability, among other features. Education, housing, health care, and other consumer goods are also multi-dimensional. Consumers are heterogeneous in the importance they place on various elements of product quality, complicating the "what-to-report?" question. It can be observed that, in many markets, perhaps due to simple cost considerations, summary measures of quality are all consumers have to go on: restaurants or hotels are graded by the number of stars in a travel guide; hospitals are ranked by an

[1] See the "Nursing Home Compare" section of the CMS website at www.medicare.gov. The major private sector effort in health care is being led by the Business Roundtable under the name, the "Leap Frog Group." See www.leapfroggroup.org.

index of quality; consumer durables are scored, though on multiple dimensions, by *Consumer Reports*.

An additional consideration enters when availability of information about quality is being decided by a public agency. Requiring producers to report elements of quality previously unobserved by consumers engages the public agency in an interaction with the buyers and sellers. New information alters consumers' beliefs about the quality of the good they are buying, and new reporting requirements alter the firm's profit calculus. In other words, a public agency can decide what information to require based on strategic considerations. This paper studies how an information reporting requirement affects the efficiency of quality choice in a context in which quality has multiple dimensions and consumers are heterogeneous in their valuations of the elements of quality. In light of what is often seen in markets – the reporting of summary indicators – we consider a range of information reporting requirements that include an "averaged" quality report. By averaged we mean a single index that is a weighting of the qualities of each attribute.

The paper sets out a model of a good with two dimensions of quality attributes sold to consumers with different valuations of these two attributes. As in education and health care, cost conditions are assumed to be such that consumers at a given supplier must share the same quality characteristics. In Section 2, the firm chooses qualities in the presence of a predetermined price. Consumers buy under various conditions of information about the attributes. We characterize the first best qualities, and the qualities that would result in the polar cases of no information and complete information. We show that requiring the firm to report an index of averaged quality can improve over the full-information outcome. In Section 3, the firm sets both price and qualities in the two dimensions, and in this case again, the averaged information report can be superior to full information. In Section 4 we move the analysis one step closer to education and health care, and let the regulator choose both price and the form of report, improving on the full information outcome, and in some cases, attaining efficient qualities.

Our analysis is inspired by policy issues in education and health care, sectors where regulators collect and publish information about the characteristics of schools, health plans and providers. Information about schools can be used to illustrate the questions we address here. Suppose that a school can allocate its resources to enhance quality in two dimentions, the quality for gifted students and the quality for typical students, but the school must report only a weighted average of the quality in the two dimensions. If quality for gifted students is 90 and quality for typical students is 75, an equally weighted quality reporting requirement, to take one possible weighting, would have the school report one number: 82.5.

The effect of information on demand is mediated by consumers' beliefs. When a parent hears "82.5," what school quality does she expect for her gifted child? The approach we take is to assume consumers' beliefs are rational in the sense of accurately anticipating what a school (or hospital) would do in its own interests to attain a given reported quality.[2] The rational parent would make different inferences when "82.5" is the equally weighted average of the two qualities from when the averaged quality is more heavily weighted to the "typical" student. The model thus forges a connection between the choices a regulator makes about the form of a quality report, and the outcomes in a market.

The assumption in our model that leads to market failure in the case of full information is elemental, stemming from the relationships between cost and demand conditions. We assume it is impossible for cost reasons to have competition in supply of every customized

[2]Tactics adopted by schools (in this case, colleges), such as refusing admission to "overqualified applicants" because it erodes a school's "acceptance rate" – a factor in the *US News and World Report* formula – are detailed in Avery, Fairbanks and Zeckhauser (2003).

set of quality attributes demanded by consumers. Heterogeneity in demand in relation to cost is more pronounced in some sectors than others, and we speak about education and health care as sectors in which consumers are forced to compromise among themselves on quality attributes (Glazer and McGuire, 2002a). A single public school serves most communities, and one or a few hospitals serve most markets. Consumers value attributes of these services differently. Informational asymmetries also characterize both of these sectors.

The idea that agents do not necessarily benefit from more information is not new to the literature and has been demonstrated in a variety of contexts. See, for example, Hirshleifer (1971), Levine and Ponssard (1977), Sakai (1985), Gal Or (1988), Mirman, Samuelson and Schlee (1994) and Schlee (1996). The basic idea, common to all these papers, as well as ours, is that the benefit to an agent from making better decisions when he is better informed is sometimes outweighed by his loss due to the fact that other agents also behave differently when information improves.

The paper closest to ours is Schlee (1996), who studies a situation where firms and consumers may be uncertain about a product's quality. Since prices are determined by the relation between marginal cost (known with certainty in his model) and marginal revenue associated with expected quality, increasing consumers' information will alter the marginal revenue function in ways, depending on cost conditions, that may make consumers worse off. Schlee's (1996) paper differs from ours in many aspects, one important one being that in our model a "product" is a collection of attributes and the "quality" of a product is, therefore, multidimensional. This multidimensionality assumption enables us to address questions that, as far as we are aware of, have not yet been addressed by the literature, such as: are consumers and/or society better off when consumers can fully observe the quality level of each of the product's attributes or would they be better off observing only a summary indicator (e.g., the average) of these different qualities? Indeed, in our model, consumers are indifferent between the case where they can fully observe the quality of each of the product's attributes and the case where they don't have any information whatsoever about these qualities, as in both cases the firm is able to extract the entire surplus from consumers. It is only in the "in-between" case where consumers can only observe the average quality of the different attributes of the product, that consumers retain some surplus. This is also the only case where the first-best quality level can sometimes be attained. This new observation opens the door to a whole set of questions such as how to construct (average) quality reporting (i.e., how much weight to assign to each attribute) if one wishes to maximize social/consumer surplus.

The analysis in our paper is also related to the literature on "multitasking" (Holmstrom and Milgrom, 1991; Prendergast, 1999). In a multitasking analysis, a firm is rewarded for performance of one among many tasks. Efficiency objectives can be frustrated if rewarding one task causes a firm to cut back on some other unrewarded task. In a billing department, requiring all consumer inquiries to be answered within 10 days (the easily monitored element of quality) might cause personnel to be less thorough in their responses (the difficult to monitor element), leading to a fall in the overall quality of the operation. The multitasking perspective implies that doing nothing might be better than a partial system of rewards. Although we are not aware of a multitasking paper that considers paying on averaged quality, the real difference between our analysis and the multitasking literature is in the mechanism of demand response for rewarding the firm. Instead of directly structuring rewards to a firm, in our paper, the regulator determines the forms of reports a firm must make. Consumers then translate these reports into demand.

Our paper is also related to a literature in health care devoted to study of how health care providers "game" reporting and payment regulations. When providers are required to report the diagnosis of a patient for purposes of payment, they may report more serious (and well-paid) diagnoses (Carter, Newhouse and Relles, 1990) or even engage in procedures required for documentation for payment in response to incentives (McClellan, 1997). In a recent paper, Dranove et al (2003) find that in response to required reports about heart surgery success rates, hospitals attempt to alter the severity of the patients they take, with the resulting reallocation of patients to hospitals having deleterious effects on aggregate quality of care. Demand response to mandated quality reports motivates this gaming. This is an example of a common problem in health care: risk-adjusted payments and comparative reports may not adequately reflect the underlying differences in "severity" of patients, inducing providers and plans to take actions to attract only profitable patients (Frank, Glazer and McGuire, 2000). The actions we are concerned about here are decisions about the quality of the product. By developing a model of how a supplier responds to ("games" if you will) a requirement of quality reporting, we can derive implications for how a regulator should decide about the form of report in the first place.

2 The Basic Model and Preliminary Results

A firm produces one product. The quality of the product has two dimensions (attributes) called 1 and 2. Let $q_i \geq 0$ denote the level of the i^{th} dimension of the product's quality, $i = 1, 2$. Let $C(q_1, q_2)$ be the cost of producing one unit of the product at quality profile (q_1, q_2).

There are two (groups of) consumers called Consumer 1 and Consumer 2. Each consumer wishes to buy, at most, one unit of the product. Let $U_i(q_1, q_2)$ be Consumer i's valuation of the product at quality profile (q_1, q_2). Because of a simplification we make about preferences in Assumption 1 below, we can use i to index both consumers and quality dimensions.

The main ideas of this paper can be illustrated with simple forms of costs and utility. We, therefore, make the following assumption:

Assumption 1:

(a) $C(q_1, q_2) = C(q_1) + C(q_2)$, where $C(0) = 0$, $C'(0) = 0$, $C'(q) > 0$ and $C''(q) > 0$, for all $q > 0$.

(b) $U_i(q_1, q_2) = V_i(q_i)$ for $i = 1, 2$ and all q_1 and q_2 where $V_i(0) = 0$, $V_i'(q_i) > 0$, $V_i''(q_i) < 0$ for all $q_i \geq 0$ and $V_1'(q) > V_2'(q)$ for all $q \geq 0$.

(c) For a given quality level q_i, Consumer i wishes to purchase one unit of the product if and only if $V_i(q_i) \geq p$, where p is the price of the product.

(d) The utility functions $V_i(q_i)$, $i = 1, 2$, are known to the producer and the cost function $C(q_1, q_2)$ is common knowledge to the producer and to both consumers.

Assumption 1(a) says that the cost of increasing quality in one dimension is the same as the cost of increasing quality in the other dimension and is independent of the quality of the other dimension. Assumption 1(b) says that Consumer i cares only about the i^{th} dimension of the product's quality and that Consumer 1 values quality more than Consumer 2. Assumption 1(c) says that the consumer wishes to purchase the product if its price is not higher than its value to the consumer. The most important element in Assumption 1(d) is that it is common knowledge that both consumers know the firm's cost function.

We assume that the firm must offer the same product to both consumers (i.e., the firm cannot offer different quality profiles of the product to different consumers). Let

$$W(q_1, q_2) = V_1(q_1) + V_2(q_2) - 2(C(q_1) + C(q_2)) \tag{1}$$

be the social welfare if both consumers purchase the product with quality profile (q_1, q_2).

Let (q_1^o, q_2^o) solve

$$V_i'(q_i^o) - 2C'(q_i^o) = 0 \quad (2)$$

for $i = 1, 2$, then (q_1^o, q_2^o) is the socially efficient quality profile.[3] Notice that by our assumptions $q_1^o > q_2^o$. Let

$$W^o = V_1(q_1^o) + V_2(q_2^o) - 2(C(q_1^o) + C(q_2^o)) \quad (3)$$

be the first-best level of social surplus.

2.1 Quality Equilibrium

We are now ready to analyze market equilibrium. To simplify the presentation we assume first that the price of the product is fixed at some level $p \geq 0$, this assumption will be relaxed in Section 3.

There are two stages in our model. In the first stage the firm chooses the quality profile (q_1, q_2). In the second stage consumers observe the price and possibly some information about the product's quality, and decide whether or not to buy the product on the basis of its price and their beliefs about the product's quality profile.

The equilibrium notion, to be called quality equilibrium, QE, consists of the firm's strategy $s^e = (q_1^e, q_2^e)$, consumers' strategies – a decision whether or not to purchase the product as a function of the product's price and their beliefs about the product's quality – and consumers' beliefs about the product's quality, such that:[4]

[3]Under certain conditions social welfare may be the highest when the firm chooses $q_2 = 0$, $q_1 > 0$ and only Consumer 1 purchases the product. We do not discuss this case in our analysis.

[4]We do not discuss mixed strategies in this paper.

1. s^e maximizes the firm's profit given consumers' strategies.

2. Each consumer strategy is optimal, for any possible information, given his beliefs.

3. In equilibrium, the consumers' beliefs are confirmed.

Our purpose is to study the effect of consumers' information about the product's quality on the market equilibrium and welfare. We will consider three cases, one where consumers cannot observe the product's quality profile (q_1, q_2) at all, the other where consumers have full information about (q_1, q_2) and the last one, where consumers cannot observe q_1 and q_2 but do observe a summary indicator (a weighted average) of the two. We will show that when consumers observe only some average of the two dimensions of the product's quality, social welfare may be higher than in the cases where they have either no information at all or full information about quality.

2.1.1 No Information

Consider first the case referred to as the N case (for no-information), where the quality profile (q_1, q_2) is not observable by consumers when they decide whether or not to purchase the product. The following proposition is straightforward:

Proposition 1: Let $s^N = (q_1^N, q_2^N)$ denote the firm's equilibrium strategy in the N case. Then $q_i^N = 0$ for $i = 1, 2$ and both consumers do not purchase the product unless $p = 0$. Social welfare in this case is $W^N = 0$.

Proof: When consumers cannot observe the product's quality the firm has no incentives to invest in quality and, in equilibrium, it is common knowledge that quality is at its lowest possible level. If $p > 0$ both consumers will not purchase the product. ■

In what follows we will assume that $p > 0$.

2.1.2 Full Information

Consider now the case referred to as the F case (for full-information), where consumers can fully observe q_1 and q_2 when they decide whether or not to purchase the product.

Proposition 2: Let $s^F = (q_1^F, q_2^F)$ be the equilibrium quality profile chosen by the firm, when consumers can fully observe q_1 and q_2 before deciding whether or not to purchase the product, then there exists $\bar{p}$ such that if $p \leq \bar{p}$, the firm will set q_i^F such that $V_i(q_i^F) = p$, for $i = 1, 2$, both consumers will purchase the product, the firm's profit will be $\pi^F = 2(p - C(q_1^F) - C(q_2^F))$ and social surplus will be $W^F = \pi^F < W^o$. (In Figure 1 we show the full-information quality profile in this case.)

Proof: In equilibrium, if the firm sells the product to both consumers, its equilibrium strategy is the solution to the following problem (later referred to as the F problem):

$$\max_{q_1, q_2} 2(p - C(q_1) - C(q_2))$$

s.t

$$V_i(q_i) \geq p \text{ for } i = 1, 2$$

The solution to this problem yields $V_1(q_1) = V_2(q_2) = p$.

In the full information case the firm may be better off selling the product only to one consumer. If the firm sells the product only to one consumer, Consumer i, say, in equilibrium, then it must be that $q_j = 0$ and q_i solves:

$$\max\ p - C(q_i)$$

s.t

$$V_i(q_i) \geq p.$$

The solution to this problem yields $V_i(q_i) = p$.

Let $(\bar{q}_1, \bar{q}_2)$, where $q_i > 0$ for $i = 1, 2$, be defined by the following two equations:

$$V_1(\bar{q}_1) = V_2(\bar{q}_2) \tag{4}$$

and

$$V_1(\bar{q}_1) - C(\bar{q}_1) - 2C(\bar{q}_2) = 0 \tag{5}$$

and let $\bar{p} = V_1(\bar{q}_1)$. One can see that if $p = \bar{p}$ the firm is just indifferent between choosing the quality profile $(\bar{q}_1, 0)$, selling only to consumer 1 and choosing the profile $(\bar{q}_1, \bar{q}_2)$ selling to both consumers. If $p < \bar{p}$ the firm is strictly better off selling to both consumers and if $p > \bar{p}$ the firm is better off selling only to Consumer 1. Furthermore, for a p sufficiently high the firm is better off not producing at all.

Since $V_i(q_i^F) = p$ for $i = 1, 2$ we know that $\pi^F = W^F$ and since $q_1^F < q_2^F$ whereas $q_1^o > q_2^o$, we conclude that $W^F < W^o$. ■

As shown in the proof of Proposition 2 above, there exists a price $\bar{p}$ such that if $p > \bar{p}$ the firm will be better off not selling the product to both consumers. We do not discuss this case here and from here on we assume that $p < \bar{p}$.

An important observation we make in Proposition 2 is that the first best quality profile (q_1^0, q_2^0) can never be an equilibrium profile in the full-information case. More specifically, even if we set $p = V_2(q_2^0)$ we will get $q_2^F = q_2^0$ but $q_1^F < q_1^0$ and if we set $p = V_1(q_1^0)$ we will get $q_1^F = q_1^0$ but $q_2^F > q_2^0$. This result will also be true if we let the firm choose the price, as discussed in Section 3 below.

2.1.3 Averaged Information

Suppose now that consumers cannot observe the level of q_1 and q_2 but they can observe some "average" quality $\bar{q}_\alpha = \alpha q_1 + (1-\alpha)q_2$. More formally, consider the following two-stage game:

Stage 1: The firm chooses (q_1, q_2)

Stage 2: Each consumer observes p and $\bar{q}_\alpha$, where $\bar{q}_\alpha = \alpha q_1 + (1-\alpha)q_2$, $0 \leq \alpha \leq 1$, and decides whether or not to buy the product.

There are two interpretations of our assumption that consumers can only observe "average" quality. One interpretation is that consumers can only observe a one-dimensional signal of the product's quality profile, such as consumers' satisfaction or the length of a waiting list. The other interpretation, which we will elaborate on more in Section 4, is that a public agency that can observe all dimensions of the product's quality strategically reveals only the average quality of the different dimensions.

We assume that α is common knowledge to the firm and both consumers and let the two-stage game above be denoted by $G_{\alpha,p}$. We shall show that in equilibrium of $G_{\alpha,p}$ the firm generally chooses a strategy different than the one it chooses in the N case and the F case (except for a particular level of α), and that equilibrium may be more efficient than the equilibria in these two cases.

Notice first that if $\alpha = 0$, the firm's equilibrium strategy, $s^e = (q_1^e, q_2^e)$, will simply be $q_1^e = 0$, $q_2^e = q_2^2$, where q_2^2 is given by $V_2(q_2^2) = p$ and only Consumer 2 buys the product. Similarly, when $\alpha = 1$ the market equilibrium is $q_1^e = q_1^1$, $q_2^e = 0$, where $V_1(q_1^1) = p$, and only Consumer 1 buys the product.

The more interesting case, however, is when $0 < \alpha < 1$. In order to get a better understanding of what happens in this case it is worthwhile to see first why the full-information equilibrium strategy s^F will generally not be an equilibrium strategy for the firm in the game $G_{\alpha,p}$.

Can (q_1^F, q_2^F) be an equilibrium strategy in $G_{\alpha,p}$? Suppose it is, and hence, by the equilibrium definition, the two consumers, when they observe the average quality $\bar{q}_\alpha^F$ where $\bar{q}_\alpha^F = \alpha q_1^F + (1-\alpha)q_2^F$, infer that $q_i = q_i^F$ for $i = 1, 2$ and they both purchase the product. However, if these are the consumers' beliefs when they observe $\bar{q}_\alpha^F$, the firm can increase its profit by deviating in the first stage to the strategy $s' = (q_1', q_2')$ such that:[5]

$$\alpha q_1' + (1-\alpha)q_2' = \bar{q}_\alpha^F \tag{6}$$

and

$$\frac{C'(q_1')}{\alpha} = \frac{C'(q_2')}{1-\alpha}. \tag{7}$$

Notice that (q_1', q_2') is the quality profile that minimizes the firm's cost of producing a unit of the product at the "average" quality $\bar{q}_\alpha^F$. Notice also that if the firm deviates in the first stage, from s^F to s', such a deviation will not be observed by the consumers since the product's average quality stays the same, $\bar{q}_\alpha^F$. Thus, by deviating from s^F to s' in the first stage of the game, the firm's revenue, in the second stage, stays the same at $2p$ (since consumers still believe that the product's quality profile is (q_1^F, q_2^F)) but the firm's costs are lower since $C(q_1', q_2') < C(q_1^F, q_2^F)$. Thus, s^F cannot generally be an equilibrium strategy.

The discussion above is essentially the proof of the following lemma, which is the heart of our analysis:

[5]Generally, (q_1^F, q_2^F) will not satisfy equation (7) below and hence will be different than (q_1', q_2'). The special case where they coincide will be discussed in Proposition 3 below.

Lemma 1: Let (q_1^e, q_2^e) be an equilibrium quality profile for the firm in the game $G_{\alpha,p}$, then it must be that:

$$\frac{C'(q_1^e)}{\alpha} = \frac{C'(q_2^e)}{1-\alpha} \tag{8}$$

Proof: If (q_1, q_2) does not satisfy (8) the firm can profitably deviate to (q_1', q_2') keeping the same average quality as in (q_2, q_2) and, hence, the same revenue, but at lower costs of production. ■

Equation (8) above will be later referred to as the Incentive Compatible Constraint (IC). An immediate implication of Lemma 1 above is that if $\alpha = \frac{1}{2}$ the equilibrium level of quality will be the same in both dimensions, i.e., $q_1^e = q_2^e$. Furthermore, $q_1^e < q_2^e$ if and only if $\alpha < \frac{1}{2}$.

While the lemma above says what must happen along the equilibriums path, it does not put any restriction on consumers beliefs (about the product's quality profile) off the equilibrium path. Indeed, one can show that for some $0 < \alpha < 1$, the game $G_{\alpha,p}$ may have different equilibria supported by different off-equilibrium beliefs by consumers. We shall focus our attention, however, on the market equilibrium that generates the highest profit to the firm when both consumers purchase the product, denoting the firm's strategy in this case by $s^e(\alpha, p)$.

Proposition 3: Let $s^e(\alpha, p)$ be the firm's strategy in the equilibrium of $G_{\alpha,p}$ in which the firm generates its highest profit and let α^F be given by

$$\frac{C'(q_1^F)}{\alpha^F} = \frac{C'(q_2^F)}{1-\alpha^F}, \tag{9}$$

where (q_1^F, q_2^F) is the full information quality profile characterized in Proposition 2. Then, if in equilibrium of $G_{\alpha,p}$ both consumers purchase the product, it must be that:

If $\alpha = \alpha^F$, $q_i^e(\alpha, p) = q_i^F$ for $i = 1, 2$

If $\alpha < \alpha^F$, $q_1^e(\alpha, p) = q_1^F$ and $q_2^e(\alpha, p) > q_2^F$

If $\alpha > \alpha^F$, $q_1^e(\alpha, p) > q_1^F$ and $q_2^e(\alpha, p) = q_2^F$

In Figure 2 the equilibrium quality profile is shown for $G_{\alpha,p}$.

Proof: If both consumers purchase the product and $(q_1^e(\alpha, p), q_2^e(\alpha, p))$ generates the highest profit in equilibrium, it must be the solution to the following problem, later referred to as the A Problem (for averaged information):

$$\max_{q_1, q_2} 2(p - C(q_1) - C(q_2))$$

s.t.

$$p \leq V_i(q_i) \text{ for } i = 1, 2.$$

and the IC constraint (8) holds.

Notice that the A Problem above is the same as F Problem, given before, with the additional IC constraint.

However, since $s^F = (q_1^F, q_2^F)$ solves the F problem and, by the definition of α^F, at $\alpha = \alpha^F$ it satisfies also the additional constraint (9), it must be that s^F is the solution to the A problem at $\alpha = \alpha^F$.

If $\alpha < \alpha^F$, the IC constraint is not satisfied at s^F and the firm must increase q_2 in order to satisfy the constraint. Notice that the firm cannot decrease q_1 below q_1^F since at q_1^F we have $V_1(q_1^F) = p$ and decreasing q_1 below q_1^F would mean violating the constraint $V_1(q_1^F) \geq p$.

Similarly, if $\alpha > \alpha^F$, the firm will keep $q_2 = q_2^F$ and will increase q_1 beyond q_1^F to satisfy the IC constraint. ■

An immediate corollary of Proposition 3 is that, unlike the "no-information" and the "full information" case, where the firm extracts the entire surplus from both consumers (i.e.,

$p = V_i$ for $i = 1, 2$), in the "averaged information" case one of the consumers obtains a strictly positive surplus, unless $\alpha = \alpha^F$.

An important interpretation of the results above is that if consumers cannot observe product quality when they decide whether or not to purchase the product, then a public agency, a Regulator that can monitor quality, may better enhance social welfare by informing consumers about only the average quality of the different dimensions of the product's characteristics rather than the exact level of quality in each dimension. By altering α, the Regulator may affect q_1 and q_2 and, hence, $W(q)$.

3 The Firm Chooses the Price As Well As Quality

Suppose that in addition to the quality profile (q_1, q_2) the firm chooses the price of the product in the first stage of the game. In the second stage consumers observe the price, but not necessarily the product's quality profile, and decide whether or not to purchase the product on the basis of the price and their beliefs about the product's quality profile. We shall let $s = (q_1, q_2, p)$ denote a strategy of the firm in this case and s^e denote an equilibrium strategy.

Following our discussion in the previous section we can see that if consumers have no information about the product's quality, equilibrium will be such that $q_1^{N'} = q_2^{N'} = p^{N'} = 0$ and $W^{N'} = \pi^{N'} = 0$. (We distinguish the cases studied in this section from the cases studied in the previous section by adding a "prime" to the notations.)

If consumers have full information about the product's quality the firm's equilibrium strategy will be the solution to the following problem, later referred to as the F′ problem:[6]

[6]Under certain conditions, equilibrium in the full information case may be such that the firm chooses to sell the product only to Consumer 1. We do not consider this case here and focus on the case where both consumers purchase the product.

$$\max_{(q_1,q_2,p)} \ 2(p - C(q_1) + C(q_2)$$

s.t

$V_i(q_i) \geq p_i \ \ i = 1, 2.$

The solution to this problem is given in the following proposition.

Proposition 4: Let $s^{F'} = (q_1^{F'}, q_2^{F'}, p^{F'})$ be the firm's strategy in the full-information equilibrium in which both consumers purchase the product, then

$$p^{F'} = V_1(q_1^{F'}) = V_2(q_2^{F'}), \tag{10}$$

$$\frac{C_1'(q_1^{F'})}{V_1'(q_1^{F'})} + \frac{C_2'(q_2^{F'})}{V_2'(q_2^{F'})} = 1 \tag{11}$$

and hence,

$$W^{F'} = \pi^{F'} = V_1(q_1^{F'}) + V_2(q_2^{F'}) - 2C(q_1^{F'}) - 2C(q_2^{F'}) < W^o. \tag{12}$$

Proof: The first two equations (10) and (11) follow from the maximization problem, F', above. The fact that $W^{F'} < W^o$ follows simply from the fact that $q_1^{F'} < q_2^{F'}$ whereas $q_1^o > q_2^o$. In Figure 3 we show the equilibrium in this case. ■

When the firm chooses the price in addition to the product's quality, it will choose the quality profile to be just enough so that each consumer purchases the product, i.e., $V_i(q_i) = p$ for $i = 1, 2$ as given in equation (10) above. This result implies, however, that $q_1^F < q_2^F$ and social surplus is not maximized.

3.1 Averaged Information

Suppose again that consumers cannot observe the level of q_1 and q_2 but they can observe some "average" quality $\bar{q}_\alpha = \alpha q_1 + (1-\alpha)q_2$. More formally, consider the following two-stage game:

Stage 1: The firm chooses (q_1, q_2, p)

Stage 2: Each consumer observes p and $\bar{q}_\alpha$, where $\bar{q}_\alpha = \alpha q_1 + (1-\alpha)q_2$, $0 \leq \alpha \leq 1$, and decides whether or not to buy the product.

Assume that α is common knowledge and let the two-stage game above be denoted by G_α. The equilibrium notion to be studied here, called quality-price equilibrium, QPE, is similar to the one defined in Section 2.1 above, with the only modification that now the firm chooses the product's price, in addition to quality, in the first stage. The first observation to make is that Lemma 1 still holds, since the firm can always deviate to the lowest cost quality profile that generates any given average quality without the consumers observing this deviation.

The second observation to make is that, here, too there may be more than one equilibrium in the game G_α. We focus again on the equilibrium where the firm generates the highest profit, denoting the firm's strategy in this case by $s^e(\alpha) = (q_1^e(\alpha), q_2^e(\alpha), p^e(\alpha))$. The equilibrium is characterized in the following proposition.

Proposition 5: Let $s^e(\alpha) = (q_1^e(\alpha), q_2^e(\alpha), p^e(\alpha))$ denote the strategy that generates the highest profit to the firm in a price-quality equilibrium of G_α, and assume that both consumers purchase the product in equilibrium, then

a) If $\alpha = \alpha^{F'}$, where $\alpha^{F'}$ is given by

$$\frac{C'(q_1^{F'})}{\alpha^{F'}} = \frac{C'(q_2^{F'})}{1-\alpha^{F'}} \tag{13}$$

and where $(q_1^{F'}, q_2^{F'})$ is given by (10) and (11), then $q_i^e(\alpha) = q_1^{F'}$, for $i = 1, 2$.

b) If $\alpha \neq \alpha^{F'}$ equilibrium will be different than equilibrium in the full-information case.

Proof: The equilibrium strategy $s^e(\alpha)$ solves the following problem, later referred to as the A' Problem (for averaged information):

$$\max_{q_1, q_2, p} 2(p - C(q_1) - C(q_2))$$

s.t.

$p_i \leq V_i(q_i)$ for $i = 1, 2$.

and the IC constraint (8) holds.

a) Notice that the A' Problem above, is the same as F' Problem presented above with the additional IC constraint. Hence, if $\alpha = \alpha^{F'}$, where $\alpha^{F'}$ is given by part a) of the proposition, the IC constraint is satisfied at $s^{F'}$ and therefore, $(q_1^{F'}, q_2^{F'}, p^{F'})$ is the firm's equilibrium strategy in $G_{\alpha^{F'}}$.

b) If, however, $\alpha \neq \alpha^{F'}$, then the solution to the A' Problem implies that, in addition to the IC constraint, either

$$i) \quad p^e(\alpha) = V_1(q_1^e(\alpha)) \leq V_2(q_2^e(\alpha)), \tag{14}$$

and

$$V_1'(q_1^e(\alpha)) = C'(q_1^e(\alpha)) \left[1 + \left(\frac{1-\alpha}{\alpha}\right)^2 \cdot \frac{C''(q_1^e(\alpha))}{C''(q_2^e(\alpha))}\right] \tag{15}$$

or

$$ii) \quad p^e(\alpha) = V_2(q_2^e(\alpha)) \leq V_1(q_1^e(\alpha)), \tag{16}$$

and

$$V_2'(q_2^e(\alpha)) = C'(q_2^e(\alpha)) \left[1 + \left(\frac{\alpha}{1-\alpha}\right)^2 \cdot \frac{C''(q_2^e(\alpha))}{C''(q_1^e(\alpha))}\right] . \tag{17}$$

These results follow from the fact that the first order conditions for the maximization problem A' above have:

$$2 - \lambda_1 - \lambda_2 = 0 \tag{18}$$

$$-2C'(q_1) + \lambda_1 V_1'(q_1) - \lambda_3 \frac{C''(q_1)}{\alpha} = 0 \tag{19}$$

$$-2C'(q_2) + \lambda_2 V_2'(q_2) - \lambda_3 \frac{C''(q_2)}{1-\alpha} = 0 \tag{20}$$

and

$$\lambda_i(p - V_i(q_i)) = 0 \quad \text{for } i = 1, 2. \tag{21}$$

Case (i) is obtained by assuming $\lambda_2 = 0$ and Case (ii) is obtained by assuming $\lambda_1 = 0$. ■

An important observation to make here is that total consumer surplus is higher in the averaged information case than in the full-information and the no-information case. More specifically, in both the full and no-information case, the firm extracts all the surplus from both consumers, whereas in the averaged information case (and unless $\alpha = \alpha^F$) one consumers surplus stays at zero (Consumer 1 (2) when $\alpha < \alpha^F(\alpha > \alpha^F)$) and the other consumer's surplus is strictly positive.

While consumers prefer the averaged information case over the full-information and the no-information case, the firm's profit is the highest in the full-information case. This raises the question of when will the social surplus (W) be the highest? The answer to this question is not straightforward. One can easily construct examples where social surplus is higher under the averaged-information case and other examples where social surplus is higher when consumers can fully observe product quality. One way to demonstrate the effect of moving away from full information to averaged information is to look at the effects on W of small changes in α around $\alpha = \alpha^F$. Let $W(\alpha)$ denote social surplus at equilibrium of G_α, then

$$\frac{dW^e(\alpha)}{d\alpha} = \frac{\partial W}{\partial q_1} \cdot \frac{dq_1^e}{d\alpha} + \frac{\partial W}{\partial q_2} \cdot \frac{dq_2^e}{d\alpha}. \tag{22}$$

At $\alpha = \alpha^{F'}$ we know that $q_1^e < q_1^0$ and $q_2^e > q_2^0$ and, hence, $\frac{\partial W}{\partial q_1} > 0$ and $\frac{\partial W}{\partial q_2} < 0$. Hence, we can conclude that if at $\alpha = \alpha^F$, $\frac{dq_1^e}{d\alpha} > 0$ and $\frac{dq_2^e}{d\alpha} < 0$, a small increase in α will increase social welfare and a small decrease in α will decrease social welfare.

Finally, the next corollary characterizes the equilibrium when consumers observe only the simple average of the two attributes of the product's quality (i.e., $\alpha = \frac{1}{2}$) and provides a sufficient condition for social surplus to be higher in this case than social surplus in the full information case. Before analyzing this case, however, it is worthwhile to note that $\alpha^{F'} < \frac{1}{2}$. This follows from Proposition 5 and the fact that $q_1^{F'} < q_2^{F'}$. Thus, observing only the simple average of the two dimensions of product quality instead of observing each of these two dimensions, is analogous to increasing α from $\alpha^{F'}$ to $\frac{1}{2}$.

Corollary 1: Suppose that $\alpha = \frac{1}{2}$ then,

(a) $q_1^e\left(\frac{1}{2}\right) = q_2^e\left(\frac{1}{2}\right) = q_2^0$ and $p^e\left(\frac{1}{2}\right) = V_2(q_2^0)$

(b) If $q_2^0 > q_1^{F'}$, then $W^e\left(\frac{1}{2}\right) > W^{F'}$.

Proof: (a) The first equality in (a) follows directly from the IC constraint. In order to obtain the second equality in (a) notice that when $q_1 = q_2$ the equilibrium strategy can be written as the solution to the following problem:

$$\max_{q_2,p} 2(p - 2C(q_2))$$

s.t.

$$p = V_2(q_2)$$

The first order condition for this problem yields:

$$V_2'\left(q_2^e\left(\tfrac{1}{2}\right)\right) - 2C'\left(q_2^e\left(\tfrac{1}{2}\right)\right) = 0 \tag{23}$$

and, hence, by (2), $q_2^e\left(\frac{1}{2}\right) = q_2^0$.

(b) Since, by the assumption in (b) and the results in (a), $q_1^{F'} < q_1\left(\frac{1}{2}\right) < q_1^0$ we know that

$$V_1\left(q_1^e\left(\tfrac{1}{2}\right)\right) - 2C\left(q_1^e\left(\tfrac{1}{2}\right)\right) > V_1(q_1^{F'}) - 2C(q_1^{F'}), \tag{24}$$

and, since $q_2^0 = q_2^e\left(\frac{1}{2}\right) < q_2^{F'}$ we know that,

$$V_2\left(q_2^e\left(\tfrac{1}{2}\right)\right) - 2C\left(q_2^e\left(\tfrac{1}{2}\right)\right) > V_2(q_2^{F'}) - 2C(q_2^{F'}). \tag{25}$$

Hence, $W^e\left(\frac{1}{2}\right) > W^{F'}$. ■

The specific results presented in the corollary above are obviously driven, among other things, by our assumption that the cost of increasing quality is the same in the two attributes of the product. However, the main purpose of this corollary is to demonstrate that social welfare can be improved if instead of providing consumers with full information about each detail of the product's quality, we only inform them about summary indicator of the average quality.

4 Regulating the Price and α

Suppose that a public regulator can set both α and the price. More formally, consider the following three-stage mechanism:

Stage 0: A Regulator announces α and p

Stage 1: The firm observes α and p and choses q_1 and q_2.

Stage 2: Consumers learn p, α and $\bar{q}_\alpha = \alpha q_1 + (1-\alpha)q_2$ and decide whether or not to purchase the product.

Notice that, for every α and p chosen by the Regulator in Stage 0, the game starting in Stage 1 is similar to the game $G_{\alpha,p}$ studied in Section 2 above. From Proposition 3 we can see that for every price p set by the Regulator, there exists an α, call it $\alpha^F(p)$, such that if the regulator sets p and $\alpha = \alpha^F(p)$, equilibrium of $G_{\alpha^F(p),p}$ will coincide with the equilibrium in the case where the Regulator only sets p and consumers have full information about quality. If, however, the Regulator sets α different from $\alpha^F(p)$, quality level in one attribute will stay the same as in the full information case but quality in the other attribute will be strictly higher (as long as the firm does not move to a zero-quality equilibrium). Thus, for every p, the Regulator can increase welfare beyond the level obtained in the full information case by altering α.

4.1 Achieving First-Best Qualities

We are now ready to show that the Regulator may be able to induce the first-best levels of quality by picking the right levels of α and p.

Proposition 6: Let (α^0, p^0) satisfy:

$$p^0 = V_2(q_2^0) \tag{26}$$

and

$$\frac{\alpha^0}{1-\alpha^0} = \frac{C'(q_1^0)}{C'(q_2^0)}, \tag{27}$$

where (q_1^0, q_2^0) is the socially efficient quality profile, and assume that:

$$p^0 - C_1(q_1^0) - C_2(q_2^0) > 0 \tag{28}$$

then, in the game G_{α^o, p^o},

$$s^e(\alpha^0, p^0) = (q_1^0, q_2^0). \tag{29}$$

Proof: If (28) holds the firm is better off choosing the quality profile (q_1^o, q_2^o) and selling one unit to each consumer at the price p^o than choosing the quality profile (0,0) and selling nothing. The rest of the proof is straightforward. ■

4.2 Regulated Prices and Demand Response to Quality in Education and Health Care

The regulated-price analysis in the previous section relates to public policy in education and health care. In both of these sectors, regulators mandate quality reports and much of the financing for education and health comes from public sources. In education, public school district budgets are driven by enrollments, the age of students and whether they enroll in special education or regular classrooms.[7] Introduction of school choice in many jurisdictions requires "vouchers" or some other price-like device parents can use to direct revenue to the school of their choice. Voucher prices are set by regulation. When students differ in ability, schools' decisions about quality are influenced by the expected revenues and costs of the types of student they might attract (Epple and Romano, 1998).

Prices paid to suppliers are highly regulated in publicly funded health care programs such as Medicare (for the elderly and disabled) and Medicaid (for the poor and disabled), and are explicitly intended to influence the quality of care supplied to public recipients. A large literature in health care addresses the issue of how to regulate health care prices to induce efficient quality (Newhouse, 2002a). The primary mechanism in this literature is based on "demand response." Consumers observe and respond to quality. By setting the price a provider (hospital/health plan/doctor) receives for attracting clients, the regulator can affect quality choice (See, e.g., Rogerson (1994); Ma (1994)). Heterogeneity in health care takes the form of heterogeneity in need/demand and cost of care. In a practice known as "risk adjustment," health plans are paid prices that differ according to age, gender and other characteristics of enrollees intended to give the plans incentives to be willing to serve all categories of potential enrollees (Newhouse, 2002b). Since quality of health plans consists

[7] For a review of the state formulae for distribution of aid to the local districts, see US DoE (2001).

of multiple attributes, the task of setting a risk adjustment policy to induce the right mix of quality is a daunting one (Glazer and McGuire, 2002b).

The literatures on risk adjustment in health care and vouchers in education take up questions of price regulation *given* some degree of observability of quality on the part of consumers. A natural next step is to consider price regulation in conjunction with policies to affect what consumers are able to observe and respond to in their choice of provider. Mandatory quality reporting and risk adjustment in health care are both policies designed to induce the right level of quality from health care providers, but they have yet to be evaluated within a unified framework.

5 Future Research

Information available to consumers about products' attributes affects demand, and therefore firms' decisions about the qualities of the products produced. Replacing the assumption that more information is better with analysis of how regulation of information affects market outcomes reveals that information about quality might best be limited, and opens many new lines of investigation. Some assumptions in our approach should be reconsidered. We restricted information available to consumers to that reported by regulation, whereas firms and consumers make decisions and interact in ways that also convey information to consumers. What firms might voluntarily declare or what information consumers might invest in finding out could be influenced by public regulation about information reporting. Our assumption about how consumers infer quality from reports also deserves theoretical and empirical scrutiny. The developing literature in "behavioral economics" could be used as a source of alternative assumptions about consumers' construction of beliefs.

As we noted earlier, integrating the literature on price regulation with mandatory quality reporting is also called for. This is a general theoretical problem, but also could be pursued within a particular application, in education or health care, such as the pricing and reporting requirements set for health plans marketing to the 40 million elderly with choice of health plan in the federal Medicare program.

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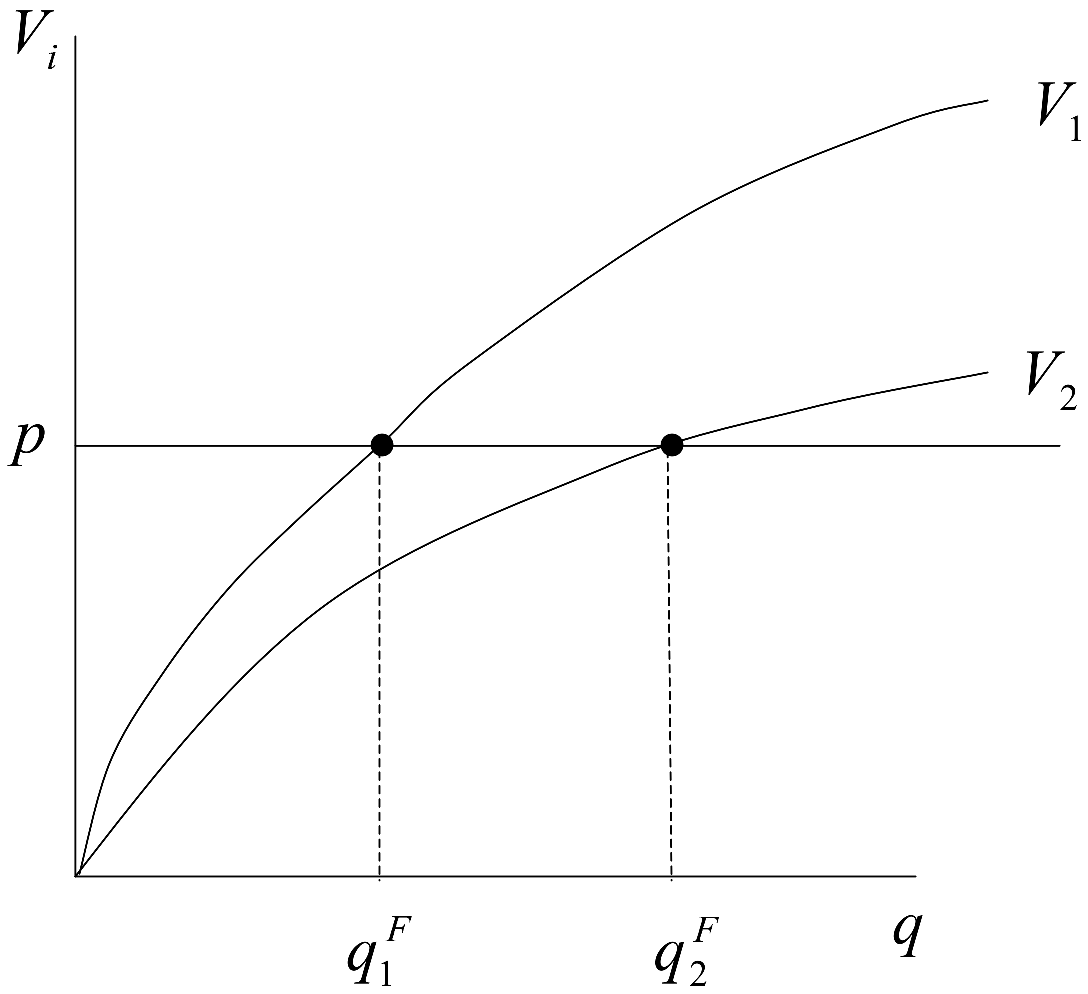
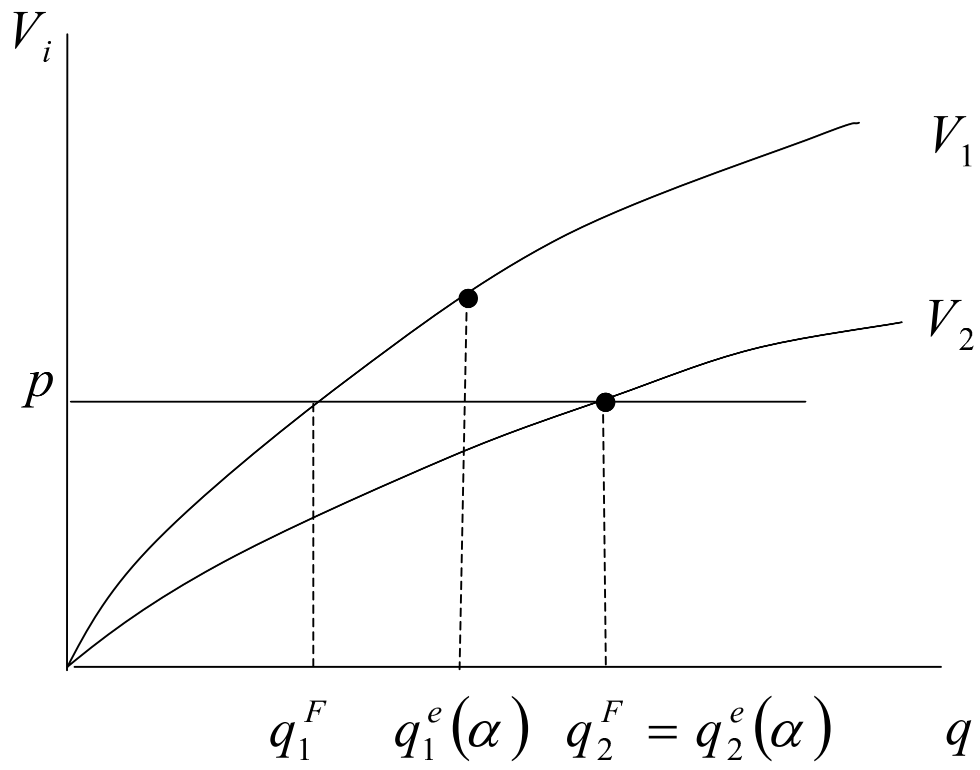
Figure 1

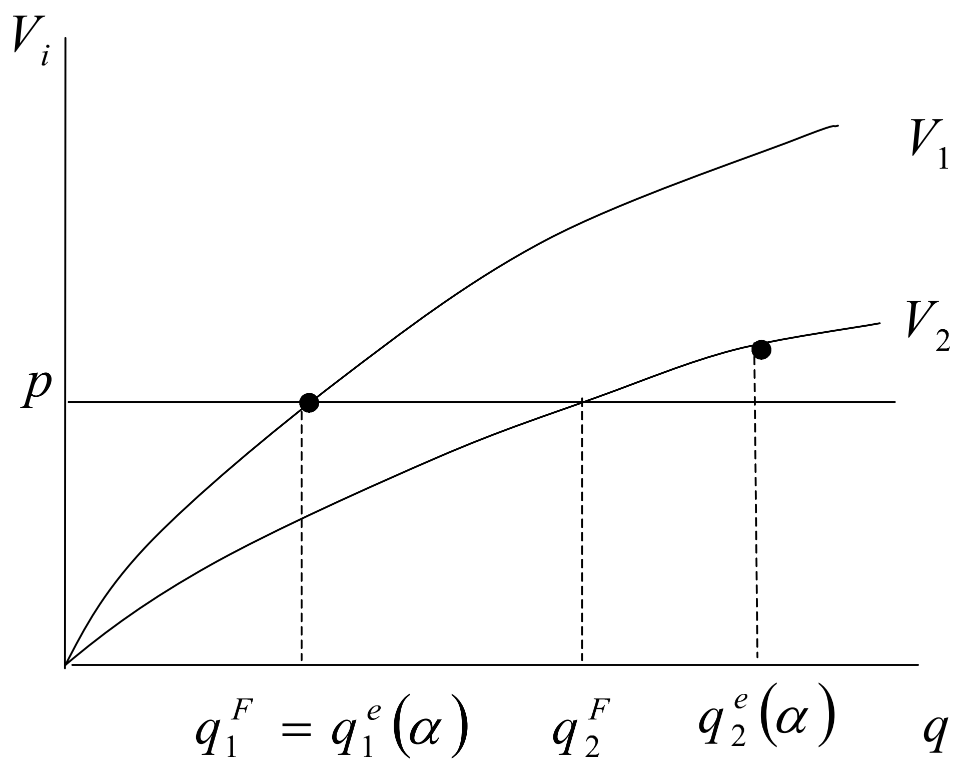


Full Information Equilibrium

Figure 2

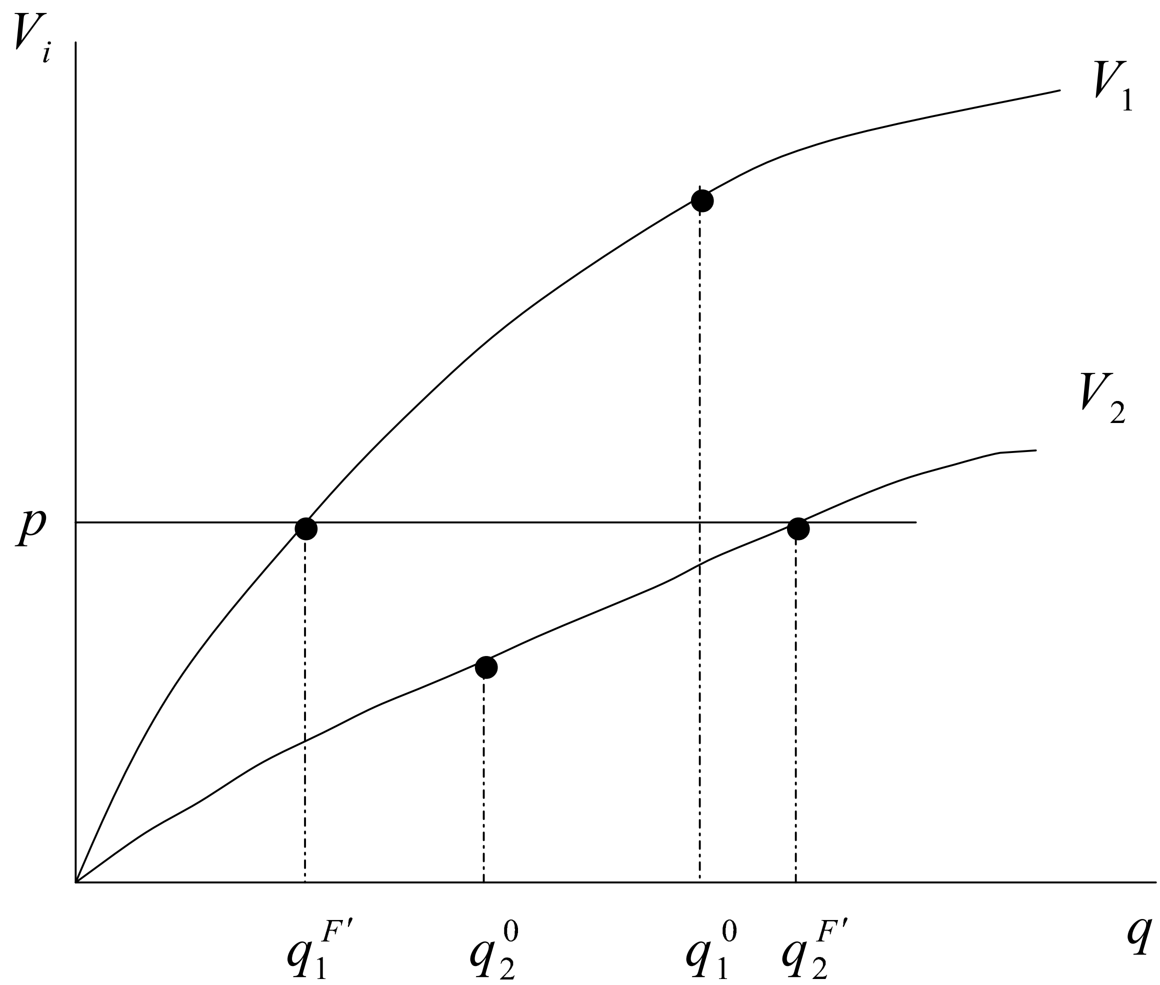


Averaged Information $\alpha > \alpha^F$



Averaged Information $\alpha < \alpha^F$

Figure 3



Equilibrium in the Full Information Case when the Firm Chooses the Price