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Price and quality competition under adverse selection: market organization and efficiency

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Firms compete with prices and qualities in markets where consumers have heterogeneous preferences and cost characteristics. Consumers demand two goods, which can be supplied jointly or separately by firms. We consider two strategy regimes for firms: uniform price-quality pairs, and screening price-quality menus. For each regime, we compare the equilibria under integration (each firm supplying both goods) and separation (each firm supplying one good). Integrating and separating markets change quality, efficiency, and welfare. The theory illustrates phenomena such as the carveout of mental health and substance abuse coverage from general health insurance, and creaming for low-cost students in locales with school choices.

1. Introduction

■ Models with adverse selection (Akerlof, 1970) have enhanced our understanding of many economic phenomena. They offer both positive and normative explanations on problems that may arise due to asymmetric information, such as the lemons problem in the automobile market (Genesove, 1993), market institutions such as expert certifiers (Biglaiser, 1993), screening by firms and employers (Cooper, 1984; Moore, 1985), and design of optimal regulatory mechanisms (Baron and Myerson, 1982; Laffont and Tirole, 1986). In fact, the methodology of including a set of incentive-compatibility constraints in a model of asymmetric information has become a standard tool of economic analysis. While the standard models have been useful, they are not rich enough to cover many recent trends in the marketplace. We address how adverse selection affects economic activities that take place across several markets.

Obviously, the standard model *can* be applied to models with many markets when adverse-selection problems in these markets occur independently. Nevertheless, how can it be applied

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when economic agents' private information is *correlated*? In this article we provide a framework to answer this problem. We address questions such as the following: Will correlation between consumers' preferences on multiple goods and costs cause these goods to be supplied in a bundle or separately? How does industry structure affect the way firms compete when adverse selection is characterized by correlated private information? How does correlation affect distortions in quality, quantity, and welfare?

We illustrate adverse selection and correlation by current developments in the health and education markets. Recent changes in the health care industry include not only those that scholars of industrial organization commonly think are important (such as horizontal and vertical mergers, entry and exit by firms, as well as explicit and implicit contracts), but also a new innovation, called a carve out. Whereas a single insurance or managed-care company used to administer general and mental health care and substance abuse coverage for enrollees, now administration of these services may be handled by separate firms. The so-called mental health and substance abuse carve outs have been implemented by such large firms as IBM, Alcan, McDonnell Douglas Helicopter, and Boeing. Furthermore, many public agencies, such as state Medicaid and state governments, have introduced carve outs.[1] (See Altman and Price, 1993; Frank and McGuire, 1997; Goldman, McCulloch, and Sturm, 1997; and Ma and McGuire, 1998.)

It has been argued that the main reason for a carve out is to solve moral hazard and adverse-selection problems.[2] A carve out is different from most incentive mechanisms (such as cost sharing, price setting, spending caps, or quantity restrictions) in that it specifically aims to change the structure of supply. Suppose that less healthy consumers value mental health and substance abuse services more than healthy ones, and it is less costly to supply healthier consumers these services. Here, the correlation is between consumers' preferences for quality of health services and costs of supplying these services to them. Because the less healthy individuals value mental health and substance abuse services more, to avoid bad risks firms may prefer to offer low-quality coverage for these services. Under a carve out, mental health and substance abuse services are offered by firms that are not allowed to supply general health services. Given the development of carve outs, the following questions naturally arise: Will firms that cannot supply general health services have less of an incentive to discriminate against the consumers? Likewise, will the general health service suppliers discriminate less? Correlation is the key, but the standard model is inadequate for analyzing this precisely because it lacks a treatment on correlation between preferences on multiple goods and costs.

The second example is school choice. The subject has garnered a great deal of discussion by policy makers, academics, and pundits. There has also been some movement toward allowing students flexibility in selecting which school they can attend. The state of Michigan enacted a school choice program in the early 1990s that created charter schools and allowed interdistrict transfers. A primary concern of many education experts was that school choice "would attract the brightest students and those with the most involved parents" (*The New York Times*, October 26, 1999). Nevertheless, this did not happen. According to David Arsen of Michigan State University, "We didn't find the academic creaming so many people worried about . . . what we found instead is creaming on the basis of costs." He goes on to say that "the charter schools were generally taking the students who are cheapest to educate and leaving behind those who are most expensive." A study he conducted also showed that "about three-quarters of the charter schools offered no special services, and even the few that did enroll special needs students provided them with fewer and less expensive services than nearby public schools."

In the case of general and special education, correlation is the issue. A student who needs special education typically requires more attention in his general education classes; the cost of educating this type of student is higher. Moreover, parents of children who are less expensive to

[1] Other kinds of carve outs have also been considered; these mostly concern chronic diseases such as diabetes and AIDS.

[2] In fact, in the Massachusetts mental health and substance abuse carve out, the stated goal was to "reduce risk fragmentation and adverse selections." See Group Insurance Commission (1992), p. 15.

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educate may not value special education as much as those parents whose children need special education. When a school offers both general and special education programs, it may lower the quality of special education to dissuade the high-cost students from enrolling. Will separating the special and general education programs in schools reduce creaming? Will it lead to higher efficiency in general or special education? Again, how does adverse selection affect the choice of supply structure?

Our model has two firms offering horizontally and vertically differentiated products. They compete by setting prices and quality levels for each of two goods. Consumers' preferences can be described by how much they value the quality of each good (the vertical dimension) and which firm they are naturally more inclined to visit (the horizontal dimension). In particular, all consumers have the same preferences about the quality of the first good, while one set of consumers values the quality of the second good more than the other set of consumers does. Firms' costs to supply a good at a given quality level depends on consumer types: consumers that value the second good's quality more are more costly for a firm to provide quality for each of the goods.

Two industry structures will be examined. The first is *integration*. Each firm offers two goods as a bundle to sell to consumers. The second is *separation.* In this regime, a firm is allowed to supply only one good; no bundling is allowed, and each of the two firms can be regarded as being split into two, each of which sells one of the two goods. These two regimes are regulatory choices; firms do not get to choose the regime in which they operate. Our focus is on how efficiently each of the market structures will perform in terms of quality provision and welfare.[3]

For each of the two industry structures, we examine two different strategy spaces for the firms. In the first, firms offer a uniform quality for each good that they sell. We call this *uniform price and quality competition*. In both integration and separation regimes, the equilibrium quality of good 1 (for which consumers have identical preferences) is efficient for the overall *population* of consumers. This efficiency result is reminiscent of Spence (1975): where consumers' marginal and average valuations for quality are identical (due to the linear demand functions used in this article), firms' profit-maximizing behavior leads to efficient quality. For good 2 (for which some consumers value the quality higher than others), the equilibrium quality is inefficient. The Spence argument is invalidated by the correlation between (heterogeneous) preferences and costs. Since low-cost consumers have a lower marginal rate of substitution between quality of good 2 and income, to attract a better mix of consumers firms lower the quality of good 2 from the efficient level in both integration and separation regimes.

To determine which regime results in more efficient good-2 quality, we identify two effects. The first is the *cost effect*. A firm has more incentive to raise the quality of good 2 when markets are separated because they avoid the higher cost of selling good 1 to the high-cost consumers. The other effect is the *purchase-economies-of-scope effect*. Separation changes the horizontal-differentiation parameter. As a result, demand functions may become more responsive to both price and quality changes. This gives a firm a larger incentive to reduce the quality of good 2 to improve its mix of consumers. When the cost effect dominates the purchase-economies-of-scope effect, then separation improves the quality of good 2. If the reverse is true, then separation reduces the quality of good 2 to a lower level. We also show that when demand functions are relatively responsive to price and quality, welfare is typically higher when markets are separated; when demand is not very responsive, welfare may fall when markets are separated.

The second strategy space allows firms to offer multiple quality levels and prices for each good—a menu of price-quality pairs. We call this *screening price and quality competition*. Due to the possibility of screening, the usual incentive-compatibility constraints will be used to derive the equilibria. We show that fully efficient qualities of both goods can arise in equilibrium under integration or separation: incentive constraints may not bind, with this more likely to occur under separated markets. If full efficiency is not possible in a regime, only the quality of good 2 will

[3] This would be a primary concern of a regulator or a firm's benefits designer. If, given equilibrium prices and qualities, consumer surplus is too low, then the planner could require a firm to pay a fixed fee for participating in the market and rebate money back to consumers.

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be inefficient; it will be too low in each regime. Both the cost and purchase-economies-of-scope effects can again be identified when good-2 equilibrium qualities are compared across regimes and the same qualitative effect holds as in the uniform price and quality competition case. Furthermore, if demand is very responsive to changes in price and quality, welfare is typically higher when markets are separated, while the reverse is possible otherwise.

Many articles examine how a firm maximizes profits when it offers multiple goods. Adams and Yellen (1976) and McAfee, McMillan, and Whinston (1989) show by examples that a monopolist may want to bundle goods rather than sell them separately.[4] This occurs even if demands are independent. Articles on the optimal pricing policy by a multiproduct monopolist when consumers are characterized by a scalar parameter include Roberts (1979) and Mirman and Sibley (1980). Wilson (1993), Armstrong (1996), and Rochet and Chone (1998) analyze models where the multiproduct monopolist faces consumers of multidimensional types and where the consumer's type is drawn from a continuous space. In each of these articles there is no adverse-selection problem, since the cost of providing a good is independent of a consumer's preferences and the firm faces no competition.

Our work is related to articles studying whether a multiproduct buyer would prefer to make purchases from a different seller for each good or from a single seller for all goods. Baron and Besanko (1992) and Gilbert and Riordan (1995) deal with contracts that are made before the sellers have private information, while in Baron and Besanko (1999), sellers have private information before contracting.[5] Our screening price and quality competition model is most closely related to the later Baron and Besanko article, since consumers have private information before they purchase. The key methodological difference between our article and this literature is that their sellers have independent cost draws.

Epple and Romano (1998) study an education model in which tuition-free public schools compete with profit-maximizing, tuition-financed private schools. The students have different abilities and incomes. Epple and Romano assume that a student's peers affect his achievement. They show that there is sorting on the basis of ability and income, where more-able students go to private schools. In our article there are no peer effects. If peer effects were present in our model, then there would be creaming on the basis of both talent and costs. Specifically, gifted students would get discounts as in Epple and Romano or the quality of gifted programs would be high, and students with learning disabilities would be discouraged from attending private schools that offer substandard special education programs.

Our results have a connection to the multitask principal-agent models of Holmström and Milgrom (1991, 1994). In these models, the principal must take into account how changing the agent's compensation on one task affects the agent's effort across tasks. The principal will often have to balance the agent's incentives. One implication of this work is that if there are no economies of scope among tasks, then it is more efficient to have different agents complete different tasks. That is, carve outs increase efficiencies.

In Section 2, we present the basic model. We then analyze the model in Section 3 when firms can choose only one quality level for each good that they produce. In Section 4, we allow the firms to choose multiple quality levels for each good that they offer. We conclude in Section 5.

2. The model

■ There is a continuum of consumers; each consumer would like to buy one unit of good 1 and one unit of good 2. Consumers are described by two random variables: (v, x), where $v \in \{v_L, v_H\}$, $v_L < v_H$, with the probability that $v = v_L$ being $\theta \in (0, 1)$, and where x is uniformly distributed on $[0, 1]$; these two random variables are independent. A consumer's (constant) valuation of

[4] For simplicity, we do not let a firm simultaneously offer packages that include both types of goods and separate packages for each good individually—the mixed-bundling case.

[5] Baron and Besanko (1999) model the single seller as an outside party proposing a contract to two producers, and then the buyer deals with the outside party.

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a unit of quality of good 1 is normalized to one. A consumer's (constant) valuation of a unit of quality of good 2 is described by v; that is, it is either v_L or v_H. The valuation of quality defines "vertical" preferences on the goods. On the other hand, the random variable x describes "horizontal" preferences on the goods, as in a Hotelling model. Sometimes we will use the terms "a v_i consumer" and "a consumer at x."

Each consumer buys from one of two firms, firm A and firm B. In different regimes, these firms may be allowed to supply one or both goods. Suppose that each firm sells both goods 1 and 2 at a total price of P. If the price at firm k, $k = A, B$, is P^k while the qualities of goods 1 and 2 at firm k are respectively q_1^k and q_2^k, then a consumer gets utilities

$$q_1^A + vq_2^A - tx - P^A \quad \text{and} \quad q_1^B + vq_2^B - t(1-x) - P^B,$$

purchasing from firms A and B, respectively, where t measures the strength of the preference defined by x, and where $v = v_L, v_H$. In other words, the firms can be thought of as located at the ends of a line of unit length and consumers are uniformly distributed on the line; the parameter t is often interpreted as the unit transportation cost. The firms cannot identify a consumer's characteristic x or valuation parameters v_L and v_H.

If the goods are not bundled, each must be purchased from a different firm. In this case, imagine each of the firms A and B as being split into two. A consumer buying these two goods from the firms located at point 0 obtains utility

$$q_1^A - sx - P_1^A + vq_2^A - sx - P_2^A;$$

if she buys the goods from the firms located at 1, her utility is

$$q_1^B - s(1-x) - P_1^B + vq_2^B - s(1-x) - P_2^B,$$

where P_1^k and P_2^k are the prices of goods 1 and 2 at firm k, $k = A, B$.

We allow the horizontal preference parameters, t and s, to be different depending on whether the goods are bundled or not. One possibility is $t = s$. If one uses the "distance" interpretation of the preference parameter, then a consumer incurs twice the travel cost to obtain the goods when they are sold separately compared to when they are bundled. Another possibility is $t = 2s$. Here, the total transportation cost is the same whether the goods are bundled or not. These possibilities can be given a "purchase-scope economies" interpretation: a consumer may or may not be able to save on transactions cost when the goods are bundled. The first possibility, $t = s$, refers to complete scope economies, whereas the second refers to the absence of economies. A more natural scenario may be $2s > t > s$, so that economies of scope exist but are incomplete. We do not formally restrict t to be smaller than $2s$, but for economic reasons and notational convenience we assume $t \geq s$. So that the demand functions are well defined and continuous, we assume that both s and t are strictly positive.

More generally, the horizontal-product-differentiation parameters t and s measure (inversely) the demand response to a change in price or quality, or how effectively a firm can change the mix of consumers (proportions of v_L and v_H consumers) by varying price and quality.[6] We will use the transportation cost interpretation for the horizontal parameters throughout the article to simplify exposition, but the reader should keep in mind the more general interpretation. In standard Hotelling models, the horizontal parameters determine firms' equilibrium profit margins. In our model, these parameters will also determine the extent of any equilibrium distortion, through their effects on firms' reactions to adverse selection.

We now describe the firms' cost structures. We assume that these firms are identical. The cost of achieving a given quality level depends on the consumer characteristic v. The cost of obtaining

[6] At an abstract level, it is not obvious that there should be any relationship between t and s, but clearly our interest is more practical.

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quality level q_1 for good 2 for a consumer with valuation parameter v_i is $c_i(q_1)$, where $i = L, H$. These cost functions are twice differentiable, strictly increasing, and strictly convex. We make the following assumption.

Assumption 1.

$$c_L(q_1) < c_H(q_1), \quad \text{and} \quad c'_L(q_1) < c'_H(q_1) \qquad \text{for all } q_1 > 0.$$

Similarly, the cost of achieving quality level q_2 for good 2 for a consumer with valuation parameter v_i is $d_i(q_2)$. Again, these cost functions are twice differentiable, strictly increasing, and strictly convex, and we make the following assumption.

Assumption 2.

$$d_L(q_2) < d_H(q_2), \quad \text{and} \quad d'_L(q_2) < d'_H(q_2) \qquad \text{for all } q_2 > 0.$$

Assumptions 1 and 2 say that the cost functions are positively correlated with the preference parameter.[7]

For later use, we now define a few benchmarks, q_1^*, q_2^*, and q_1^{i*}, $i = L, H$, by the following:

$$\begin{aligned}
q_1^* &= \operatorname{argmax} q_1 - \theta c_L(q_1) - (1-\theta)c_H(q_1) \\
q_2^* &= \operatorname{argmax} \theta[v_L q_2 - d_L(q_2)] + (1-\theta)[v_H q_2 - d_H(q_2)] \\
q_1^{i*} &= \operatorname{argmax} q_1 - c_i(q_1), \qquad i = L, H \\
q_2^{i*} &= \operatorname{argmax} v_i q_2 - d_i(q_2), \qquad i = L, H.
\end{aligned}$$

These six values refer to various efficient quality levels for the two goods. The first, q_1^*, refers to the efficient quality of good 1 with respect to the expected cost $\theta c_L(q_1) + (1-\theta)c_H(q_1)$; q_2^*, the efficient quality of good 2 with respect to the expected cost $\theta d_L(q_2) + (1-\theta)d_H(q_2)$. The others refer to the efficient qualities of the goods with respect to the specific type of consumer preferences. We assume that $q_2^{L*} < q_2^{H*}$ so that the first-best quality levels for good 2 are increasing with the valuations.[8]

We now interpret our model using the health care and school choice examples from the Introduction. First, we discuss the health care industry. Good 1 is general health care and good 2 is mental health care. Higher quality refers to higher measures of health status. This can be achieved by better-qualified medical staff (such as specialists instead of general practitioners, and psychologists and psychiatrists instead of social workers for mental health services), and more timely processing of consumers' treatment requests, as well as better medical facilities. Our model says that all consumers have the same preferences for general health care quality, while some consumers value mental health care quality more (the type-v_H consumers). The cost of achieving a quality level of general or mental health care depends on consumer characteristics. Some patients are more costly to treat than others because they will use more resources. According to Assumptions 1 and 2, this cost is higher for a type-v_H consumer. Generally, patients who are more severely ill require more resources, and they cost more to treat. Suppose that a patient who suffers from a more severe mental illness values the quality of mental health services more. Furthermore, suppose that severity between mental health and general health problems are positively correlated. Then our Assumptions 1 and 2 follow.

[7] Cost correlation can be modelled explicitly. Let γ_{ij} be the proportion of consumers who have cost function $\hat{c}_i$ for good 1 and preferences v_j for good 2. Define $\alpha \equiv \gamma_{LL}/(\gamma_{LL} + \gamma_{HL})$ and $\beta \equiv \gamma_{LH}/(\gamma_{LH} + \gamma_{HH})$. The expected costs of providing L- and H-type consumers good 1 at quality q_1 are $\alpha\hat{c}_L(q_1) + (1-\alpha)\hat{c}_H(q_1) \equiv c_L(q_1)$ and $\beta\hat{c}_L(q_1) + (1-\beta)\hat{c}_H(q_1) \equiv c_H(q_1)$. If $\alpha > \beta$, then the cost of providing good 1 and the preference for good 2 are positively correlated.

[8] This is a sufficient, but not necessary, condition for separation to occur in the screening model of Section 4. If this condition did not hold, then there might only be a pooling equilibrium, which would be the one in the uniform-quality model of Section 3.

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In the education market, good 1 is general education and good 2 is special education. Quality can be defined as achieving proficiency in subjects, where teacher qualifications, student-teacher ratios, and educational resources such as books and computers are used to achieve these standards. All parents prefer their children to have high-quality general education. However, some children will benefit from special education more than others, and therefore some parents value special education more (those consumers with parameter v_H).[9] If children who need and value special education, such as remedial reading and math, will need more attention in their regular classes, then Assumptions 1 and 2 hold. We assume, following the spirit of the voucher programs, that a school cannot reject any student who chooses to enroll. Furthermore, one can view the prices as, in part, property taxes.

In the article, consumers make decisions on the purchase of two goods simultaneously. For both health and education markets, this is reasonable. Why should consumers also consider mental health coverage when they select health plans? Waiting until one becomes mentally ill may be too late. The incidence of mental illness and demand for mental health services are high: Frank and McGuire (2000) report that 30% of the U.S. population is estimated to experience some diagnosable mental illness each year, whereas about 18% of the U.S. population consume some form of mental health care, according to the National Comorbidity Survey. Very few employees can switch between health plans more than once a year. Private purchase of mental health insurance after one becomes mentally ill runs the risks of preexisting-condition exclusions. Consumers should consider both general and special education when they choose domiciles and schools. Again, waiting until one's children need special education may be too late. A family will have to incur high moving costs if suitable special education services are not locally available.

We examine two different strategy spaces for this game. In the first, a firm can offer only a single quality level q_i for each good that it produces. In many applications, firms may be unable to offer multiple quality levels. This may be true in health care: it can be very costly to provide different qualities of care to patients who are being treated in the same facility. Furthermore, some consumers may resent being treated as second-class customers if more than one service quality is provided. This may lower consumers' value for the firm's services. Finally, by offering different service qualities, a firm may increase the possibility of medical malpractice lawsuits. Obviously, if firms can offer only a single set of quality levels, they must offer only one set of prices for the goods. In the second game, firms may offer multiple quality levels. Here, firms can sell a good at different qualities and at different prices. In other words, although firms cannot observe consumers' characteristics, they may still implement self-selection among consumers by offering a menu of qualities and prices. Clearly, given that consumers' valuation of good 2 can only be either v_L or v_H, it is sufficient to let each firm offer at most two quality levels (with corresponding prices).

If the markets are separated (a carve out of market 2), then for each setup firms offer a quality and a price for each good, and consumers can pick good 1 from one of the firms and good 2 from the other. Alternatively, one could think of there now being two firms at each location, with one firm providing only good 1 and the other firm providing only good 2.

The timing of the game is the following. At stage 1, firms simultaneously choose the quality levels and prices. At stage 2, consumers observe the firms' choices and choose the bundle that gives them the highest utility level. We assume that for the parameters in the model, all consumers buy both goods in a symmetric equilibrium.[10]

3. Uniform price and quality competition

■ In this section, a firm chooses a single quality level for each good that it produces. First, we examine the model when consumers must buy goods 1 and 2 from the same provider: the products

[9] Similar to the health care market, some students will require more resources from teachers and so are more costly to educate.

[10] In the Appendix we derive the sufficient conditions for the existence of pure-strategy equilibria for one of the models. The same exercise can be done for the other models.

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are bundled. Next, we examine the model when a consumer can choose from different providers for each good.

□ **Integrated market.** In integrated markets, the two goods are bundled. Suppose that firm B chooses price $\overline{p}$, and quality levels $\overline{q}_1$ and $\overline{q}_2$ for goods 1 and 2 respectively. If firm A chooses price p, and quality levels q_1 and q_2, then its demand from type v_i consumers is

$$x_i = \frac{1}{2} + \frac{q_1 - \overline{q}_1 + v_i(q_2 - \overline{q}_2) - p + \overline{p}}{2t},$$

where $i = L, H$, while the demand functions for firm B are $1 - x_i$. Since the probabilities of a consumer having valuations of v_L and v_H are respectively θ and $1 - \theta$, firm A's expected profit function is

$$\begin{aligned}\pi_A = \theta &\left\{\frac{1}{2} + \frac{q_1 - \overline{q}_1 + v_L(q_2 - \overline{q}_2) - p + \overline{p}}{2t}\right\}[p - c_L(q_1) - d_L(q_2)] \\ &+ (1-\theta)\left\{\frac{1}{2} + \frac{q_1 - \overline{q}_1 + v_H(q_2 - \overline{q}_2) - p + \overline{p}}{2t}\right\}[p - c_H(q_1) - d_H(q_2)].\end{aligned}$$

Firm A picks the price and qualities to maximize its expected profit, given firm B's choices. We look for a symmetric equilibrium, so we differentiate the above expected-profit functions with respect to p, q_1, and q_2, set the first-order derivatives to zero, and then solve the equations by letting firms use the same strategy. After simplification, we obtain the following:

$$t = p - \theta\,[c_L(q_1) + d_L(q_2)] - (1-\theta)\,[c_H(q_1) + d_H(q_2)] \tag{1}$$

$$[\theta c_L'(q_1) + (1-\theta)c_H'(q_1)]t = p - \theta\,[c_L(q_1) + d_L(q_2)] - (1-\theta)\,[c_H(q_1) + d_H(q_2)] \tag{2}$$

$$[\theta d_L'(q_2) + (1-\theta)d_H'(q_2)]t = \theta v_L\,[p - c_L(q_1) - d_L(q_2)] + (1-\theta)v_H\,[p - c_H(q_1) - d_H(q_2)]. \tag{3}$$

Equation (1) states that the equilibrium price is equal to total expected costs plus a markup of t. This is a standard result in spatial differentiation models. From (1) and (2) we obtain

$$\theta c_L'(q_1) + (1-\theta)c_H'(q_1) = 1. \tag{4}$$

The equilibrium quality level q_1 equates the expected marginal cost of good 1 to its marginal value (which has been normalized at one): equilibrium quality of good 1 is efficient with respect to the overall consumer population. For the equilibrium quality of good 2, we combine (1) and (3) to obtain

$$\begin{aligned}&\theta d_L'(q_2) + (1-\theta)d_H'(q_2) \\ &\quad = \theta v_L + (1-\theta)v_H - \frac{\theta(1-\theta)}{t}\{c_H(q_1) + d_H(q_2) - c_L(q_1) - d_L(q_2)\}\,[v_H - v_L].\end{aligned} \tag{5}$$

By Assumptions 1 and 2, the term inside the curly brackets in (5) is positive. So quality is too low relative to the efficient level because the marginal costs are strictly convex functions of qualities. That is, in equilibrium,

$$\theta d_L'(q_2) + (1-\theta)d_H'(q_2) < \theta v_L + (1-\theta)v_H.$$

Furthermore, the size of the distortion increases with the cost difference in supplying quality to v_H and v_L consumers, but falls with transportation cost parameter t. This will be important when comparing the differences in quality supplied across integrated and separated markets.

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From Spence (1975) we know that generally, quality in a market equilibrium will be efficient when consumers' marginal and average valuations of quality are identical. Our model uses linear demand functions: marginal and average valuations of quality are always equal for each type of consumers. Moreover, by symmetry, the equilibrium allocation of numbers of consumers across the two identical firms is efficient. Yet the market equilibrium quality for good 2 is suboptimal. What is the intuition?

In the standard model of the Spence class, a profit-maximizing firm uses its product quality to raise the willingness to pay of the marginal consumer (who is just indifferent between buying from this firm and another), and then sets a price just high enough to extract this surplus from the marginal consumer. When demand functions are separable, the valuations of qualities by the marginal and all inframarginal consumers are identical; a firm may just as well offer the most efficient level of quality for consumers, and then set an appropriate price-cost margin.

Our model differs from the standard model in that consumers may have different valuations of qualities. Consumers' valuations of quality of good 1 are homogeneous, while those of good 2 are not (although for each class of consumers with a given valuation of good 2, their marginal and average valuations are always the same). This invalidates the procedure of maximizing profit by offering a bundle of goods with efficient qualities to consumers and then extracting the surplus by setting an appropriate price-cost margin. Consider the derivatives of the profit function with respect to q_1 and q_2 respectively:

$$\begin{aligned} &-\theta x_L c_L'(q_1) - (1-\theta)x_H c_H'(q_1) + \frac{\theta}{2t}\left[p - c_L(q_1) - d_L(q_2)\right] \\ &\quad + \frac{(1-\theta)}{2t}\left[p - c_H(q_1) - d_H(q_2)\right] \end{aligned} \tag{6}$$

$$\begin{aligned} &-\theta x_L d_L'(q_2) - (1-\theta)x_H d_H'(q_2) + \frac{\theta v_L}{2t}\left[p - c_L(q_1) - d_L(q_2)\right] \\ &\quad + \frac{(1-\theta)v_H}{2t}\left[p - c_H(q_1) - d_H(q_2)\right], \end{aligned} \tag{7}$$

where $x_i, i = L, H$, are the demands. There are two types of consumers, but a firm sets a single price for the bundled good. For good 1, consumers' demands respond to a change in q_1 independently of their type. To see this, notice that the last two terms of (6) are weighted only by each type's proportions in the market, θ and $(1-\theta)$. Because of this independence, the relevant profit margin is still the difference between the bundled price p and the expected cost $\theta c_L(q_1) + (1-\theta)c_H(q_1)$. This profit margin represents the return to investing in quality q_1, and the way to maximize profit by choosing q_1 proceeds in the same way as in the Spence class of models.

For good 2, the demand responds to a change in q_2 depending on whether the consumer is of type v_L or v_H: the last two terms of (7) have the type-dependent price-cost margin weighted by the respective valuations v_L and v_H times the proportions of the consumer types. In other words, the relevant profit margin is no longer the bundled price p less the expected cost $\theta d_L(q_2)+(1-\theta)d_H(q_2)$ (as in (6)). By Assumptions 1 and 2, we have $p - c_L(q_1) - d_L(q_2) > p - c_H(q_1) - d_H(q_2)$, so that the profit margin associated with a type-v_H consumer is lower.

Consider the differences in marginal rates of substitution (MRS) between quality and income across consumer types. Each type has the same MRS with regard to good 1; thus there is no possible gain for a firm to discriminate on good 1. On the other hand, the type-v_L consumers have a lower MRS for good 2 than do the v_H consumers. Because a firm obtains a higher profit margin with the type-v_L consumers, it has an incentive to lower the quality level of good 2. The deviation would be profitable, since there would be a greater than $(1-\theta)$ proportion reduction in the high-cost v_H consumers. In fact, an "optimal" deviation would have the firm also lowering its price. This can be seen in our model by noting that the equilibrium price is always equal to expected cost plus the unit transportation cost t. In sum, letting equilibrium qualities be q_i^B $i = 1, 2$, we now state Proposition 1.

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Proposition 1. Under uniform price-quality competition in the integrated market (each firm offering uniform levels of quality of its goods to consumers), the equilibrium quality of good 1 is efficient, $q_1^B = q_1^*$, and the equilibrium quality of good 2 is lower than the efficient level, $q_2^B < q_2^*$.

Our discussion of the intuition for Proposition 1 already indicates that as long as firms are unable to distinguish consumers who have heterogeneous preferences on qualities, the incentives to choose quality for good 2 may be too low. Firms are unable to maximize profits by first choosing the efficient level of quality and then extracting the surplus by setting an appropriate level of price.[11]

We now interpret our results for the school choice example from the Introduction. To explain the school choice example of creaming of low-cost students by private schools not offering any special or gifted education programs, we have to make some slight modifications to the model. Suppose firm A is a private school that can choose the levels of general education, good 1, and special education, good 2. Firm B is a public school that is required by law to offer special education of quality $\overline{q}_2$ or more. Both schools receive a fixed voucher for each student who enrolls. Our interpretation of the facts that private schools offered no or limited special education is this: Given the voucher offered by the state, $\overline{q}_2$ would be above the equilibrium choice for each school for special education. The private school would then choose the quality of special education that would be less than $\overline{q}_2$ to push off the costlier students to the public schools. This will induce a disproportionate number of students who need special education to choose public schools. Furthermore, this will cause the average cost of educating a student in public school to be higher than in private school. This analysis casts some doubt on the claim that public schools are less efficient than private schools. Due to adverse selection, private schools can turn out better test scores even when public and private schools are equally efficient.

The fundamental problem of adverse selection cannot be completely avoided even if the two goods are unbundled, because the heterogeneity of consumers will continue to exist. But will unbundling alleviate the extent of quality underinvestment in the market where consumers' preferences are heterogeneous? We now turn to answer this question by analyzing equilibria of the separated markets.

□ **Separated markets.** In this setting, a firm sells the two goods separately and at different prices. It is easy to show that the equilibrium quality of good 1 satisfies equation (4) and is efficient for the population. Furthermore, the equilibrium market price for good 1 is $p^1 = s + \theta c_L(q_1^*) + (1-\theta)c_H(q_1^*)$. This is because consumers' preferences for quality of good 1 are homogeneous. We now turn to the equilibrium for good 2 when it is not bundled with good 1.

Firm A's demand from type-i consumers in market 2 is now

$$x_i = \frac{1}{2} + \frac{v_i(q_2 - \overline{q}_2) - p^2 + \overline{p}^2}{2s},$$

where p^2 and $\overline{p}^2$ are the prices set for good 2 by firms A and B, respectively, and $i = L, H$. The profit function for firm A in market 2 is

$$\pi_A = \theta \left[\frac{v_L(q_2 - \overline{q}_2) - p^2 + \overline{p}^2 + s}{2s} \right] [p^2 - d_L(q_2)]$$
$$+ (1-\theta) \left[\frac{v_H(q_2 - \overline{q}_2) - p^2 + \overline{p}^2 + s}{2s} \right] [p^2 - d_H(q_2)].$$

[11] To induce firms to choose the efficient quality level of good 2, prices must be regulated *above* the equilibrium price. An earlier version of the article derived the price that would implement the efficient quality for good 2. This price, however, would push the quality of good 1 to be higher than the efficient level.

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Again, we look for a symmetric equilibrium, so we differentiate the profit function and set $p^2 = \overline{p}^2$ and $q_2 = \overline{q}_2$. The first-order derivatives with respect to p^2 and q_2 are

$$\theta x_L + (1-\theta)x_H - \frac{\theta}{2s}(p^2 - d_L(q_2)) - \frac{1-\theta}{2s}(p^2 - d_H(q_2)) \tag{8}$$

$$-\theta x_L d_L'(q_2) - (1-\theta)x_H d_H'(q_2) + \frac{\theta}{2s}v_L(p^2 - d_L(q_2)) + \frac{1-\theta}{2s}v_H(p^2 - d_H(q_2)). \tag{9}$$

Setting the above first-order derivatives to zero to characterize the equilibrium price and quality,

$$p^2 = s + \theta d_L(q_2) + (1-\theta)d_H(q_2) \tag{10}$$

$$\theta d_L'(q_2) + (1-\theta)d_H'(q_2) = \theta v_L + (1-\theta)v_H - \frac{\theta(1-\theta)}{s}[d_H(q_2) - d_L(q_2)][v_H - v_L]. \tag{11}$$

By Assumptions 1 and 2, the last term of (11) is negative, and the quality of good 2 is again below the efficient level. The intuition follows from the discussion just before Proposition 1. Because of the difference in demand responses from the two types of consumers, a firm's incentive to invest in quality is lower than the efficient level.[12]

Now we compare the levels of quality across the integration and separation regimes. To do this, we examine equations (5) and (11), which characterize the integrated and separated market equilibrium good-2 quality levels. We will demonstrate two countervailing effects that occur when markets are separated. First, suppose that $t = s$ and take the q_2 that satisfies equation (5). At this quality level, the right-hand side of (11) is greater than the left-hand side, since the right-hand side of (5) differs from the right-hand side of (11) by the term $-\frac{\theta(1-\theta)}{t}\{c_H(q_1) - c_L(q_1)\}[v_H - v_L] < 0$. Due to the convexity of the cost functions, to make (11) an equality, q_2 must be raised closer to the efficient quality level. Thus, when $t = s$ (perfect purchase-scope economies), the equilibrium quality of good 2 is closer to the efficient level when the markets are separated. This is the *cost effect* that occurs when markets are separated; separation gives a firm an incentive to raise the quality of good 2 and attract more v_H consumers because the adverse selection in good 1 is no longer present.

Next, we demonstrate the second effect by holding s fixed and allowing t to grow; thus, the purchase economies become lower. In the limit, as t gets very large, the distortion in quality of good 2 goes to 0 when markets are integrated. Thus, for a given s, there exists a large-enough t so that the quality of good 2 is higher when the markets are integrated than separated. This second effect is the *purchase-scope-economies effect*; it gives a firm an incentive to lower the quality of good 2 when markets are separated, because consumer demand is more responsive when $s < t$. For example, take the case when $t = 2s$, no purchase-scope economies. If firm 1 lowers the quality of good 2, a type-H consumer who is horizontally close to firm 1 can switch his demand to firm 2 for good 2, without incurring the horizontal-product-differentiation cost of having to switch good 1 as well. If the cost effect dominates, then there are *information economies* when markets are separated; if the purchase-scope-economies effect dominates, then there are *information diseconomies* when markets are separated.

Let q_i^S denote the equilibrium quality in market i when the markets are separated. We collect our results for quality provision in Proposition 2.

Proposition 2. Under uniform price-quality competition in the separated markets, the equilibrium quality of good 1 is efficient, $q_1^S = q_1^*$, and the quality of good 2 is too low relative to the efficient level, $q_2^S < q_2^*$. If $t = s$, then separating the markets results in a higher equilibrium quality of good 2, $q_2^S > q_2^B$. The positive difference between the good-2 equilibrium qualities in the separation and integration regimes decreases as t grows relative to s. For every s there exists t^* such that for all $t > t^*$, $q_2^S < q_2^B$.

[12] Again, full efficiency in the quality of good 2 can be achieved if the price is regulated. An earlier version of this article shows how this price can be chosen.

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Using the sum of consumer surplus and profits as a welfare measure, we next compare welfare across the integration and separation regimes. In equilibrium, the quality of good 1 is the same, so all that matters to welfare is the quality of good 2 and the consumers' transportation costs. We write down the welfare indexes in the integration and separation regimes, respectively:

$$\theta\left[q_1^* - c_L(q_1^*) + v_L q_2^B - d_L(q_2^B)\right] + (1-\theta)\left[q_1^* - c_H(q_1^*) + v_H q_2^B - d_L(q_2^B)\right] - \frac{t}{4},$$
$$\theta\left[q_1^* - c_L(q_1^*) + v_L q_2^S - d_L(q_2^S)\right] + (1-\theta)\left[q_1^* - c_H(q_1^*) + v_H q_2^S - d_L(q_2^S)\right] - \frac{s}{2}.$$

The terms inside square brackets are welfare indexes from qualities; the other terms are due to transportation costs. Now, from Proposition 2, we know that when $t = s$, quality is higher and closer to the efficient level under separation. Nevertheless, when $t = s$, the total transportation cost under separation is twice as much as under integration. If s and t are sufficiently small, then the gain in quality efficiency from separation must dominate the higher transportation cost. From Proposition 2, as t grows, the quality difference shrinks. So if both t and s are large, the transportation costs grow under both regimes and the transportation cost can become the dominant welfare difference determinant. The welfare difference depends on both the relative and absolute magnitudes of t and s; we have just argued:

Corollary 1. Consider the uniform price-quality competition model. (i) There exist $\varepsilon > 0$ and $\delta > 0$ such that for all $t < \varepsilon$ and $t - s < \delta$, welfare is higher under separation than integration. (ii) There exist $\gamma > 0$ and $\xi > 0$ such that for all $s > \gamma$ and $t - s < \xi$, welfare is higher under integration than separation.

4. Screening price and quality competition

■ In this section, each firm is allowed to expand its strategy set by offering to consumers a set of price-quality combinations of each good.

□ **Integrated markets.** In this subsection, the two goods are bundled. Now, a firm can offer consumers two triples when competing against its rival. Firm A will offer a menu consisting of two sets of price-quality combinations: $\{(p^L, q_1^L, q_2^L), (p^H, q_1^H, q_2^H)\}$. Without loss of generality, let type-v_i consumers pick item (p^i, q_1^i, q_2^i), $i = L, H$, from the menu. For these choices to be optimal for consumers, the following two incentive-compatibility constraints must hold:

$$q_1^L + v_L q_2^L - p^L \geq q_1^H + v_L q_2^H - p^H \tag{12}$$
$$q_1^H + v_H q_2^H - p^H \geq q_1^L + v_H q_2^L - p^L. \tag{13}$$

Inequality (12) says that the type-v_L consumers will pick the item indexed by L; similarly, (13) states that v_H will pick the item indexed by H. Suppose that firm B offers the incentive-compatible menu $\{(\bar{p}^L, \bar{q}_1^L, \bar{q}_2^L), (\bar{p}^H, \bar{q}_1^H, \bar{q}_2^H)\}$; then if firm A offers $\{(p^L, q_1^L, q_2^L), (p^H, q_1^H, q_2^H)\}$, its profit is

$$\pi_A = \theta\left[\frac{q_1^L - \overline{q}_1^L + v_L(q_2^L - \overline{q}_2^L) - p^L + \overline{p}^L + t}{2t}\right]\left[p^L - c_L(q_1^L) - d_L(q_2^L)\right]$$
$$+ (1-\theta)\left[\frac{q_1^H - \overline{q}_1^H + v_H(q_2^H - \overline{q}_2^H) - p^H + \overline{p}^H + t}{2t}\right]\left[p^H - c_H(q_1^H) - d_H(q_2^H)\right]. \tag{14}$$

The first-best qualities are characterized by the following first-order conditions: $c_L'(q_1^{L*}) = c_H'(q_1^{H*}) = 1$, $d_H'(q_2^{L*}) = v_L$, and $d_H'(q_2^{H*}) = v_H$. Can the efficient qualities be an equilibrium outcome when firms compete by offering menus of quality and price combinations? Key to this

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are the following properties of the first-best qualities:

$$q_1^{L*} + v_L q_2^{L*} - c_L(q_1^{L*}) - d_L(q_2^{L*}) \geq q_1^{H*} + v_L q_2^{H*} - c_H(q_1^{H*}) - d_H(q_2^{H*}) \tag{15}$$

$$q_1^{H*} + v_H q_2^{H*} - c_H(q_1^{H*}) - d_H(q_2^{H*}) \geq q_1^{L*} + v_H q_2^{L*} - c_L(q_1^{L*}) - d_L(q_2^{L*}). \tag{16}$$

These respectively say that if each consumer pays the cost of production, then a type-v_L consumer will prefer to receive the goods with efficient qualities for type-v_L consumers, and vice versa for a type-v_H consumer. In other words, if (15) and (16) are satisfied, and if there is a constant markup over costs, then the first best may be incentive compatible. In fact, the following is straightforward to prove:

Proposition 3. Under screening price-quality competition in the integrated market (each firm offering price-quality combinations of its goods to consumers), there is a symmetric equilibrium in which each firm offers the menu $\{(p^L, q_1^{L*}, q_2^{L*}), (p^H, q_1^{H*}, q_2^{H*})\}$, where $p^i = t + c_i(q_1^{i*}) + d_i(q_2^{i*})$, $i = L, H$ if and only if inequalities (15) and (16) are satisfied. That is, qualities of all goods are efficient, and the price-cost margin of each bundled good is t.

Under the conditions of Proposition 3, each type of consumer obtains the type-specific, first-best, efficient qualities for both goods. In contrast, the efficient level of quality for good 1 in Propositions 1 and 2 only refers to one that maximizes $q_1 - \theta c_L(q_1) - (1-\theta)c_H(q_1)$, the expected population surplus.

Inequality (15) always holds. Indeed, by definition,

$$q_1^{L*} + v_L q_2^{L*} - c_L(q_1^{L*}) - d_L(q_2^{L*}) > q_1^{H*} + v_L q_2^{H*} - c_L(q_1^{H*}) - d_L(q_2^{H*}).$$

By Assumptions 1 and 2, $c_L(q_1) < c_H(q_1)$ and $d_L(q_2) < d_H(q_2)$ for all q_1 and q_2. Thus, the above inequality implies (15). On the other hand, inequality (16) may be violated. By definition, we have $q_1^{H*} - c_H(q_1^{H*}) < q_1^{L*} - c_L(q_1^{L*})$. If $v_H q_2^{H*} - d_H(q_2^{H*}) \leq v_H q_2^{L*} - d_L(q_2^{L*})$, inequality (16) is violated. Our assumptions do not permit us to sign the difference between $v_H q_2^{H*} - d_H(q_2^{H*})$ and $v_H q_2^{L*} - d_L(q_2^{L*})$.[13] The following "quadratic" example illustrates both the satisfaction and violation of inequality (16). Let $c_L(q) = .5\sigma_L q^2$, $c_H(q) = .5\sigma_H q^2$, $d_L(q) = .5\tau_L q^2$, and $d_H(q) = .5\tau_H q^2$, with $\sigma_L < \sigma_H$ and $\tau_L < \tau_H$. Then $q_1^{L*} = 1/\sigma_L$, $q_1^{H*} = 1/\sigma_H$, $q_2^{L*} = v_L/\tau_L$, and $q_2^{H*} = v_H/\tau_H$. Our assumption that $q_2^{L*} < q_2^{H*}$ requires $v_L/\tau_L < v_H/\tau_H$. Fix σ_L and σ_H at 1 and 1.25 respectively. For $v_L = 95$, $v_H = 100$, $\tau_L = 49$, and $\tau_H = 50$, the inequality is violated. For $v_L = 2$, $v_H = 4$, $\tau_L = 1$, and $\tau_H = 1.1$, the inequality is satisfied.[14]

By Proposition 3, if (16) is violated, then either (12), (13), or both bind. So now assume that (16) is violated. In this situation, the symmetric equilibrium must be given by the solution of the maximization of (14) subject to (12) and (13) (after symmetry is imposed on the solution).

To proceed, we consider a relaxed program, (RP-H): the maximization of (14) subject to (13) and $q_2^L \leq q_2^H$. In (RP-H), the incentive constraint (12) has been dropped. Obviously, constraint (13) must bind in the solution of (RP-H); otherwise the allocation in Proposition 3 would be the solution to (RP-H), but this contradicts the assumption that (16) is violated. Moreover, when constraint (13) binds, the missing constraint (12) reduces to $q_2^L \leq q_2^H$, so that the solution of (RP-H) is the solution of the original program of the maximization of (14) subject to (12) and (13).

The solution of (RP-H) is characterized by the first-order conditions after the strategies of the two firms are set to be identical. Letting λ be the Lagrangian multiplier for (13), we find that qualities q_1^L, q_1^H, and q_2^H are all set at the efficient levels: $q_1^L = q_1^{L*}$, $q_1^H = q_1^{H*}$, and $q_2^H = q_2^{H*}$, where $c_L'(q_1^{L*}) = c_H'(q_1^{H*}) = 1$ and $d_H'(q_2^{H*}) = v_H$. The equilibrium conditions for q_2^L, p^L, and

[13] See the Appendix to see when inequality (16) is most likely satisfied.

[14] The Excel program for these calculations is available from the authors.

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p^H are

$$d'_L(q_2^L) = v_L - \frac{2\lambda(v_H - v_L)}{\theta} \tag{17}$$

$$p^L - c_L(q_1^{L*}) - d_L(q_2^L) = t + \frac{2\lambda t}{\theta} \tag{18}$$

$$p^H - c_H(q_1^{H*}) - d_H(q_2^{H*}) = t - \frac{2\lambda t}{1-\theta}. \tag{19}$$

From $\lambda > 0$ and the convexity of d_L, the quality of good 2 for type-v_L consumers will be too low. Also, because we assumed that $q_2^{L*} < q_2^{H*}$, the monotonicity requirement in program (RP-H), ($q_2^L \leq q_2^H$), is satisfied. The quality q_2^L being suboptimal is typical in adverse-selection models: if the incentive constraint binds for a v_H consumer, then a v_L consumer's quality is depressed in order to satisfy the constraint optimally. Reducing q_2^L is superior to raising q_2^H: since $v_H > v_L$, lowering q_2^L from the efficient level introduces a second-order loss for type v_L but a first-order gain for fulfilling the incentive constraint for type v_H.

It will be useful to characterize the size of the distortion when we compare the equilibria of integrated and separated markets. Using (13) to substitute for p^H in equation (19) and subtracting (18) from (19), we obtain

$$(q_1^{L*} - q_1^{H*}) + v_H(q_2^L - q_2^{H*}) + c_H(q_1^{H*}) + d_H(q_2^{H*}) - c_L(q_1^{L*}) - d_L(q_2^L) = \frac{2\lambda t}{\theta(1-\theta)}.$$

Using equation (17) to substitute out for λ, we find that

$$d'_L(q_2^L) = v_L - \frac{(1-\theta)(v_H - v_L)}{t} \times \left[q_1^{L*} - c_L(q_1^{L*}) + v_H q_2^L - d_L(q_2^L) - q_1^{H*} + c_H(q_1^{H*}) - v_H q_2^{H*} + d_H(q_2^{H*})\right]. \tag{20}$$

We can now state the following result.

Proposition 4. Under screening price-quality competition in the integrated market, if (16) is violated, the symmetric equilibrium is the solution to (RP-H). That is, $q_1^L = q_1^{L*}$, $q_1^H = q_1^{H*}$, $q_2^H = q_2^{H*}$ and are efficient, while q_2^L is lower than q_2^{L*} and given by (20) The equilibrium prices are in (18) and (19).

We have now completely characterized the symmetric equilibria when firms can compete by offering price and quality combinations to screen consumers. The quality of good 1 is always efficient when screening is possible: consumers reveal their cost types through selecting items from a menu, and their preferences for good 1 are homogeneous. Nevertheless, there are other kinds of distortions for the quality of good 2. Under uniform quality and price competition, the equilibrium quality of good 2 is always too low relative to the expected costs. Under screening competition, equilibrium quality for good 2 may be fully efficient with respect to each type of consumer (when the first best is an equilibrium), or it is too low for type-v_L consumers but efficient for type-v_H consumers (when the first best is infeasible due to the violation of (16)).

□ **Separated markets.** We now allow markets to be separated. In the last subsection, under integration and screening competition, each consumer always obtains his type-specific efficient quality for good 1, q_1^{L*} or q_1^{H*}. Somewhat surprisingly, it turns out that having efficient qualities for good 1 remains an equilibrium allocation even when markets are separated. Consider a menu of price-quality pairs for good 1: $\{(p_1^L, q_1^L), (p_1^H, q_1^H)\}$. Because consumers have homogeneous preferences, all incentive constraints for truthful revelation must bind:

$$q_1^L - p_1^L = q_1^H - p_1^H. \tag{21}$$

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Nevertheless, the binding incentive constraints do not imply distortion in quality. In a truth-telling equilibrium, a type-v_L consumer picks (p_1^L, q_1^L); a type-v_H consumer picks (p_1^H, q_1^H). Facing an opponent offering an incentive-compatible menu, firm A chooses a menu to maximize

$$\theta\left[\frac{q_1^L - \overline{q}_1^L - p_1^L + \overline{p}_1^L + s}{2s}\right]\left[p_1^L - c_L(q_1^L)\right] + (1-\theta)\left[\frac{q_1^H - \overline{q}_1^H - p_1^H + \overline{p}_1^H + s}{2s}\right]\left[p_1^H - c_H(q_1^H)\right]$$

subject to (21). After symmetry is imposed on the solution, we have the symmetric equilibrium.

Before we present the equilibrium, we note that this equilibrium is somewhat unusual. Each consumer must be indifferent between all items if a firm offers a nondegenerate menu of price-quality pairs. In this equilibrium, a type-v_i consumer picks an optimal item that is also "labelled" for that type. This allows us to construct an equilibrium with qualities specifically efficient to the valuation types. Solving the first-order conditions, we show that in the symmetric equilibrium, the qualities satisfy $c_L'(q_1^L) = c_H'(q_1^H) = 1$. The symmetric equilibrium prices are $p^L = c_L(q_1^L) + s - (1-\theta)[q_1^H - c_H(q_1^H) - q_1^L + c_L(q_1^L)]$ and $p^H = c_H(q_1^H) + s + \theta[q_1^H - c_H(q_1^H) - q_1^L + c_L(q_1^L)]$. Besides this "separating" equilibrium, there are other equilibria.[15] For example, there is a "pooling" equilibrium in which the qualities for both types are q_1^*; this is supported by a consumer's strategy of always picking a fixed item when a menu is offered—say, pick the first of all optimal items. We study the separating equilibrium because it yields the highest social welfare.

What explains the type-specific efficient qualities in the separating equilibrium? Because consumers have homogeneous preferences on good-1 quality, given any price pair, for incentive compatibility the difference between the qualities for the two types of consumers must be constant (see (21)). Raising or reducing this difference will not relax any incentive constraint. Due to the linearity of the demand functions and the Spence argument, a firm has an incentive to set quality to the type-specific efficient level in the separating equilibrium, and in that equilibrium, a firm must use distorted prices to satisfy the incentive constraint (21). This explains why p_1^H is higher than the expected price-cost margin of s, while p_1^L is lower. The equilibrium expected profit for each firm is exactly the same as if consumers' types were known to the firm.

Now, we investigate the equilibria in market 2 in the separation regime. The analysis proceeds in much the same way as when markets are integrated, except that the variables for market 1 are eliminated. For example, firm A's profit function can be obtained by deleting the terms involving variables for market 1 in (14), and the incentive-compatibility constraints for consumer types v_L and v_H are

$$v_L q_2^L - p_2^L \geq v_L q_2^H - p_2^H \tag{22}$$
$$v_H q_2^H - p_2^H \geq v_H q_2^L - p_2^L. \tag{23}$$

As in the integrated market, the properties of the first-best good-2 qualities will be key for characterizing the equilibria. Consider the following two inequalities:

$$v_L q_2^{L*} - d_L(q_2^{L*}) \geq v_L q_2^{H*} - d_H(q_2^{H*}) \tag{24}$$
$$v_H q_2^{H*} - d_H(q_2^{H*}) \geq v_H q_2^{L*} - d_L(q_2^{L*}). \tag{25}$$

They correspond to (15) and (16), and they say that if a consumer is asked to pay for the cost, a type-i consumer will prefer the type-specific efficient quality. It is straightforward to prove the following proposition.

[15] We thank a referee for pointing out these possibilities.

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Proposition 5. Under screening price-quality competition in market 2, there is a symmetric equilibrium in which each firm offers the price-quality menu $\{(s+d_L(q_2^{L*}), q_2^{L*}), (s+d_H(q_2^{H*}), q_2^{H*})\}$ if and only if inequalities (24) and (25) hold.

If (15), (16), (24), and (25) are all satisfied, then market equilibria under integration and separation will yield the same profile of (efficient) qualities of good 2 to consumers. As in the earlier discussion, inequality (24) is always satisfied, while inequality (25) may be violated. The analysis for the case in which (25) is violated proceeds in a fashion parallel to that in the previous subsection, and we will be brief. For completeness, we will write down firm A's profit function when it offers $\{(p_2^L, q_2^L), (p_2^H, q_2^H)\}$:

$$\pi_A = \theta \left[\frac{v_L(q_2^L - \overline{q}_2^L) - p_2^L + \overline{p}_2^L + t}{2s} \right] \left[p_2^L - d_L(q_2^L) \right] + (1-\theta) \left[\frac{v_H(q_2^H - \overline{q}_2^H) - p_2^H + \overline{p}_2^H + t}{2s} \right] \left[p_2^H - d_H(q_2) \right]. \tag{26}$$

If (25) is violated, then using the same arguments in Proposition 4, the symmetric equilibrium is given by the solution to the maximization of (26) subject to the binding constraint (23), and $q_2^L \le q_2^H$; the other incentive constraint (22) is slack. The equilibrium quality of good 2 for consumers with valuation v_H remains efficient at q_2^{H*}, while q_2^L is below the efficient level, and it is the solution to

$$d_L'(q_2^L) = v_L - (v_H - v_L)\frac{1-\theta}{s}\left[v_H q_2^L - d_L(q_2^L) - v_H q_2^{H*} + d_H(q_2^{H*}) \right]. \tag{27}$$

We summarize the result in the following proposition.

Proposition 6. Under screening price-quality competition in market 2, if (25) is violated in the symmetric equilibrium, $q_2^H = q_2^{H*}$, while $q_2^L < q_2^{L*}$ and is given by (27).

Before we compare the equilibrium quality levels across regimes, we point out that whether an incentive constraint binds when markets are integrated or separated does *not* depend on the transportation cost parameters t and s; this can be seen by examining inequalities (15), (16), (24), and (25). The transportation cost parameters only affect the level of distortion *if* an incentive constraint binds: see Propositions 4 and 6.

The key to comparing equilibrium qualities across the integration and separation regimes lies in the interdependence between the incentive properties of the first best in these two regimes. In fact, inequalities (24) and (25) are obtained respectively from inequalities (15) and (16) by subtracting the possible surpluses of good 1. But the magnitudes of these surpluses depend on the consumer's type: $q_1^{L*} - c_L(q_1^{L*}) > q_1^{H*} - c_H(q_1^{L*})$; inequality (24) implies inequality (15), while inequality (16) implies inequality (25). This asymmetry is crucial because the equilibrium qualities are given by constrained maximizations. Thus, switching between regimes may make constraints more or less stringent.[16] We now state the following:

Corollary 2. Suppose that the equilibrium is given by Proposition 6 (so that inequality (25) is violated under separation). Then there exists $\varepsilon > 0$, such that switching the regime from separation to integration results in less-efficient qualities in good 2 for all consumers if $t - s < \varepsilon$.

In this case, inequality (25) being violated implies that (16) is also violated, so the switch of equilibria is from Proposition 6 when the markets are separated to Proposition 4 when markets are integrated. To compare the distortions across the two regimes in this situation, take the difference

[16] Because inequalities (15) and (24) are always satisfied, we do not analyze the relationship between them.

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between the right-hand sides of (20) and (27):

$$\frac{1}{s}\left[v_H q_2^L - d_L(q_2^L) - v_H q_2^{H*} + d_H(q_2^{H*})\right] \\ - \frac{1}{t}\left[q_1^{L*} - c_L(q_1^{L*}) + v_H q_2^L - d_L(q_2^L) - q_1^{H*} + c_H(q_1^{H*}) - v_H q_2^{H*} + d_H(q_2^{H*})\right], \quad (28)$$

which is negative for $s = t$ because the first-best surplus of good 1 for type-v_L consumers is larger than that for type-v_H consumers. Thus, for $s = t$, firms will distort q_2^L less when markets are separated. So there are *information economies* for good 2 when markets are separated and $t = s$. This is because only the *cost effect* is present when $t = s$. Nevertheless, the quality q_2^L is decreasing in t due to the purchase-economies-of-scope effect. If t is large enough, (28) may become positive (similar to the case of uniform price-quality competition above) and there are *information diseconomies* when separating good 2.

In the previous corollary, the binding incentive constraint was the same whether markets are integrated or separated. Now we examine the opposite case, where an incentive constraint may be completely relaxed due to a regime change.

Corollary 3. Suppose that the equilibrium is given by Proposition 4 (so that inequality (16) is violated under integration). Then there exist parameters such that (25) is satisfied and a first best occurs; if (25) is not satisfied, then the first best is not an equilibrium under separation, and there exists $\varepsilon > 0$, such that the quality of good 2 is more efficient for all consumers if $t - s < \varepsilon$.

Separation makes it more likely that the quality of good 2 will be efficient. If (16) is violated when the markets are integrated, then there are two possibilities when markets are separated. If (25) is still violated, then the distortion for v_H consumers is smaller by expression (28) when t is not excessively bigger than s. If both (24) and (25) are slack, then each type of consumer obtains the efficient quality of good 2; see Proposition 6. Corollary 3 describes a situation where separation must improve quality efficiency. Table 1 summarizes our results on equilibrium quality q_2^H.

Finally, we compare the difference in welfare when an integrated market is switched to a separated market. Since q_1^L, q_1^H, and q_2^L are efficient in both regimes, we need only examine the quality q_2^H and the transportation costs for welfare comparisons. With one important exception, our conclusions are the same as in the uniform-quality/price-competition model. First we discuss the similarities. Suppose that both (16) and (25) are violated, so that q_2^H is less than the efficient level in both regimes. As in the uniform model, if the transportation costs are sufficiently small, the quality distortion dominates the difference in transportation costs. From Corollary 2, if t and s are close to each other, quality q_2^H is more efficient under separation than integration; if t is much larger than s, then the reverse is true. If both t and s are quite large, then the quality distortions are small relative to the transportation costs. We summarize these arguments as follows:

Corollary 4. Consider the screening price-quality competition model and suppose that both (16) and (25) are violated. (i) There exist $\varepsilon > 0$ and $\delta > 0$ such that for all $t < \varepsilon$ and $t - s < \delta$, welfare is higher under separation than integration. (ii) There exist $\gamma > 0$ and $\xi > 0$ such that for all $s > \gamma$ and $t - s < \xi$, welfare is higher under integration than separation.

TABLE 1 Quality q_2^H Based on Market Structure

	(25) satisfied	(25) violated
(16) satisfied	Efficient	Impossible
(16) violated	Efficient under separation Too low under integration	Both regimes inefficiently low quality Small $t - s$, higher quality under separation Big $t - s$, higher quality under integration

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TABLE 2 **Welfare Comparisons Based on Market Structure**

	(25) satisfied	(25) violated
(16) satisfied	Welfare higher if markets are: integrated and $t < 2s$ separated and $t > 2s$	Impossible
(16) violated	Welfare higher if markets are: separated and $t > 2s$ integrated if s big and $t - s$ small	Welfare higher if markets are: separated if t and $t - s$ small integrated if s big and and $t - s$ small

Finally, welfare comparisons in the screening competition model may be qualitatively different from the uniform competition model. This is because the first best is possible under screening competition. If both (16) and (25) are satisfied, then the quality q_2^H, along with the other quality levels, is efficient under both regimes. Welfare is then decided solely by transportation costs. Nevertheless, it is possible that inequality (16) may be violated while (25) holds. Then q_2^H becomes first best only if the markets are separated (see Corollary 3). Using similar arguments as in Corollary 4, we obtain the following:

Corollary 5. Consider the screening price-quality competition model. (i) If both (16) and (25) are satisfied, then welfare is higher under integration than separation if and only if $t \leq 2s$. (ii) If (16) is violated but (25) is satisfied, welfare is higher under separation than integration when $2s \leq t$; also, there exist $\gamma > 0$ and $\xi > 0$ such that for all $s > \gamma > t/2$ and $t - s < \xi$, welfare is higher under integration than separation.

We summarize our results regarding welfare in Table 2.

5. Conclusions

■ We analyzed a model where firms compete across multiple dimensions to attract consumers when adverse selection and correlation are present. Our focus was on whether separating markets improved or reduced the quality efficiency of the goods. We identified two countervailing effects that affected the equilibrium quality in both models: the cost effect and the purchase-economies-of-scope effect. Under both uniform and screening competition, if there are large purchase economies of scope, then separation improves the quality of the good where consumers have heterogeneous preferences. If the purchase economies of scope are small, then separation may reduce the quality when consumers have heterogeneous preferences. Furthermore, separating markets does not change the quality of a good when consumer preferences are identical. We also examined the welfare difference under integration and separation of markets. If the purchase economies of scope are large and the transportation costs are small, then welfare is typically higher when markets are separated. On the other hand, when the purchase economies of scope are small and the transportation costs are high, typically welfare is higher when markets are integrated.

Our model does present some complicated issues for policy analysis. In practice, a change in market structure is often accompanied by many other policy instruments. For example, in the Massachusetts mental health and substance abuse carve out, tight price regulations, together with health care provider networks and managed care, were introduced simultaneously with the carve out. (See Ma and McGuire (1998) for more details.) These other policy instruments perhaps represent the recognition that a change in market structure alone may have complex welfare implications.

We have not discussed firms' entry decisions. While the Hotelling model is not ideal for this purpose due to endpoint problems, we offer a few remarks. First, our model applies to a straightforward entry scenario. If there are two potential entrants, and upon entry a firm is located at an endpoint, then our analysis describes the equilibrium of this game. Second, if the firms have

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fixed locations, while product qualities of one of the firms are also fixed, then our discussion on the education market after Proposition 1 sheds some light on what can occur. Third, to model entry decisions in an interesting way, a circle model (Salop, 1979) would be better.[17] We may in the future pursue the issue of entry in a multiple-good adverse-selection environment.

Some recent work in health economics has shown that insurance premiums should be adjusted for individual risk characteristics to reduce the adverse-selection problem (see Cutler and Reber, 1998; Glazer and McGuire, 1999). Our analysis is complementary to this work. One could interpret our work as showing that if risk-adjusted premiums are used to reduce the adverse-selection problem, then separating the market may reduce insurance costs.

One way to obtain efficiency in the school choice example is to raise the voucher price for all students so that the private school has incentives to raise the quality of special education. Another, less-costly plan would be to give higher vouchers to students who are designated as needing special education. A third alternative is to mandate minimum requirements for special education programs in order for a private school to be eligible for a voucher. Finally, special and general education programs could be unbundled; students can receive the two services from different providers. This may be very impractical, since there may be large economies of scope for providing all of a student's educational needs at one location or by one provider.

Appendix

■ **Existence of pure-strategy equilibria.** We now provide sufficient conditions for the existence of a pure-strategy equilibrium for market 2 in the uniform-quality model when markets are separated. For a pure-strategy equilibrium to exist, three conditions must be met: the strategy sets are nonempty and compact, the objective functions are continuous, and the objective functions are quasi-concave in each firm's strategy; see Friedman (1986) for examples. Clearly, the objective functions are continuous, and it is easy to define the strategy space to be on $[0, M]$, for M sufficiently large. Thus, we need to focus on whether the objective function is quasi-concave. A sufficient condition for quasi-concavity is that $(-1)^n Det(A_n) > 0$ for each of the n principal minors of the matrix of second derivatives. The matrix of second derivatives is

$$\begin{bmatrix} -\dfrac{1}{s} & \dfrac{1}{2s} + \dfrac{\theta d_L'(q_2) + (1-\theta)d_H'(q_2)}{2s} \\ \dfrac{1}{2s} + \dfrac{\theta d_L'(q_2) + (1-\theta)d_H'(q_2)}{2s} & -\dfrac{\theta d_L'(q_2)(v_L+1)}{2s} - \theta d_L''(q_2)x_L - \dfrac{(1-\theta)d_H'(q_2)(v_H+1)}{2s} - (1-\theta)d_H''(q_2)x_L \end{bmatrix}.$$

Clearly, the first minor is always negative. The sign of the second minor is equivalent to

$$\frac{\theta d_L'(q_2)v_L}{2} + \theta s d_L''(q_2)x_L + \frac{(1-\theta)d_H'(q_2)v_H}{2} + (1-\theta)sd_H''(q_2)x_L$$
$$- \frac{1}{4} - \left[\frac{\theta d_L'(q_2) + (1-\theta)d_H'(q_2)}{2}\right]^2.$$

For $d_L''(\cdot)$ and $d_H''(\cdot)$ sufficiently large, the second minor is positive for any any set of parameters. Thus, there exist conditions under which a pure-strategy equilibrium exists for any positive s. The same exercise can be done for the other models in the article.

□ **Inequality (16).** To see under what circumstances (16) is likely satisfied, define

$$G \equiv q_1^{H*} + v_H q_2^{H*} - \eta_H^1 c_H(q_1^{H*}) - \eta_H^2 d_H(q_2^{H*}) - q_1^{L*} - v_H q_2^{L*} + \eta_L^1 c_L(q_1^{L*}) + \eta_L^1 d_L(q_2^{L*}),$$

where the η's are shift parameters increasing the cost of supplying the good. Taking derivatives with respect to v_L, v_H, and each of the η parameters, we find

$$\frac{\partial G}{\partial v_L} = -\frac{\partial q_2^{L*}}{\partial v_L}\left[v_H - \eta_L^1 d_L'(q_2^{L*})\right];$$

[17] For a Hotelling model with two firms already located at the endpoints, it seems obvious that any entrant will locate itself at the midpoint. The model then reduces to a pair of models, each being isomorphic to our original model without entry.

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$$\frac{\partial G}{\partial v_H} = q_2^{H*} - q_2^{L*};$$
$$\frac{\partial G}{\partial \eta_H^1} = -c_H(q_1^{H*});$$
$$\frac{\partial G}{\partial \eta_L^1} = c_L(q_1^{L*});$$
$$\frac{\partial G}{\partial \eta_H^2} = -d_H(q_2^{H*});$$
$$\frac{\partial G}{\partial \eta_L^2} = \frac{\partial q_2^{L*}}{\partial \eta_L^2}\left[-v_H + d_L'(q_2^{L*})\right] + d_L(q_2^{L*}).$$

Thus, (16) is more likely satisfied the smaller v_L, the larger v_H, the lower the cost of suppling both goods to the type-H consumers, and the higher the cost of supplying goods to the type-L consumers.

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