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QUACKS, LEMONS AND LICENSING REVISITED

Michael R. Metzger

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ABSTRACT

In markets with asymmetric quality information, quality deterioration may occur as indicated by Akerlof [1970], resulting in a "lemons" market. Such deterioration, often cited as justification for minimum quality standards and occupational licensing, was concluded by Leland [1979] to be a general phenomenon in markets with asymmetric quality information. This paper employs an analytical model similar to that developed by Leland, but revised so as to correct a methodological error and to loosen the assumption of a one-to-one relationship between quality and quantity supplied. Support is found for Leland's conclusion that a "lemons market" is a general phenomenon in competitive markets characterized by asymmetric information, as well as the conclusion that a minimum quality standard may or may not be socially desirable in such markets. These results rebut the use of a "lemons market" rationale as a single criteria for minimum quality standards and occupational licensing. Accordingly, market characteristics are identified to distinguish those markets in which standards might be socially beneficial. In markets characterized by decreasing opportunity costs, the analysis refutes Leland's conclusions that quality will be generally under-supplied, that output always will be over-supplied, and that licensing will always be desirable. A minimum quality standard (or licensing) self-imposed by a profession is also investigated. Within Leland's static model in which the profession seeks to maximize producer surplus in the form of industry profits, no support is found for the presumption that a profession would be likely to set a standard in excess of the social optimum. However, this issue is probably best addressed in an intertemporal framework in which there is entry and in which the professional group is assumed to maximize producer surplus only for the incumbent providers. Finally, the analysis is used to investigate the use of minimum quality standards as applied to quality enhancing activities, such as education. Such standards may or may not be socially desirable. This conclusion is unchanged even when the activity permits screening of suppliers as to innate ability.

I. Introduction

Minimum quality standards have been adopted over the years for countless products and professional services, typically in response to the existence of imperfect information and the perceived need for consumer protection. For products, minimum quality standards have been applied to such diverse items as medical drugs, auto safety and fuel efficiency features, electrical appliances, foods, clothing, and cosmetics. In addition, occupational licensing has been applied to a wide range of professions from medical doctors and lawyers to hair dressers and interior decorators.

Theoretical justification for minimum quality standards was first established by Akerlof (1970) when he showed in the context of the used auto market that informational asymmetry could lead to market failure. Subsequently, Leland (1979) presented a more general information-theoretic analysis of markets with asymmetric information. From this analysis, Leland concluded that in such markets: (1) quality would be supplied at sub-optimal levels; (2) minimum quality standards may or may not be socially desirable, depending on certain demand and supply characteristics which he identified; and (3) a professional group or industry if allowed to set its own standards, could set such standards too high or too low, but that "on balance, there is some reason to expect too-high standards to be the more likely case."[1]

Subsequently, Shapiro (1986) examined occupational licensing in markets characterized by asymmetric information, employing three assumptions not made in the Leland analysis, namely that: (1) the quality of professional services is subject to control through the expenditure of time, effort, and investment in human capital; (2) reputations can be built over time; and (3) licensing is implemented as a restriction on inputs (e.g., human capital investment) rather than on the service quality level. In employing these assumptions (which are admittedly more descriptive of many markets for professional services than those employed by Akerlof and Leland), Shapiro created a model and obtained results distinctively different from his predecessors. However, in explaining the dynamics of markets with asymmetric information, his analysis represents more of a complement than a substitute to the work of Akerlof and Leland.

This paper continues in the vein of Akerlof and Leland. It first makes some needed corrections in the underlying analysis of Leland's paper, most notably, the definition of total social surplus, but leaves intact, for the most part, his broad conclusions (cited above). In addition, the model is elaborated to better distinguish quality and

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[1] Leland (1979), p. 1342.

quantity implications of minimum quality standards and licensing.[2] Finally, the analysis is applied to a scenario similar to that studied by Shapiro in that it assumes quality enhancing activities occur and are the focus of minimum quality standards, but dissimilar in not assuming reputation-building.

In Sections II and III, a corrected version of Leland's model is developed and applied to minimum quality standards. The correction involves the definition of social welfare, on which all judgments of optimality are based. In addition, the model is generalized so as to relax the one-to-one relationship between quality and quantity supplied. Section IV extends the analysis to markets best characterized by opportunity costs that increase with quality. Section V investigates self-regulation of quality by a professional group. In Section VI, the model is adapted to incorporate quality-enhancing activities (such as investment in human capital) that are often the subject of minimum quality standards. A conclusion follows in Section VII.

II. A Model of Markets with Asymmetric Information

The analytical model employed here is adapted from Leland. Variables are defined as follows:

q = quality of product,
$f(q)$ = number of sellers at quality level, q,[3]
x = $F(q)$ = cumulative function specifying the quantity of product with quality less than or equal to q,
$R(q)$ = opportunity cost of supplying a unit of product with quality level, q,
$P(q,x)$ = inverse demand function giving price willing to be paid by consumers as a function of quality and total quantity supplied.

The following assumptions are adopted:

(1) While each supplier is assumed to have an output of one unit as Leland assumed, suppliers are not necessarily distributed uniformly in the quality dimension. Instead, the cumulative distribution function is given by:

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[2] For the purposes of this paper, no distinction is made between licensing and minimum quality standards.

[3] Consistent with Akerlof's example and Leland's model, it is assumed that the potential supply of product at each quality level is fixed. This supply is either offered for sale or not, depending on the market price.

$$x = F(q) = \int_0^{q'} f(q)\, dq; \tag{1}$$

(2) the opportunity cost schedule is upward sloped,[4] i.e.,

$$R_q > 0; \tag{2}$$

(3) demand is characterized by

$$P_q > 0, \qquad (P_{qq} \leq 0), \tag{3}$$
$$P_x < 0. \tag{4}$$

A. *Market Equilibrium*

Information is assumed asymmetric in the sense that sellers know the quality of their product (or service) but buyers do not. Suppliers base their decision on the actual quality of their product; hence, the supply price is simply the opportunity cost schedule, i.e., $P_s = R(q)$. As in Leland's model, buyers are assumed here to behave on the basis of average quality, $\bar{q}$,[5] so that demand price is given by $P_d = P(\bar{q},x)$.

Equilibrium is defined by that quality level, q', for which the marginal willingness to pay (as a function of the average quality) equals the supply price:

$$R(q') = P(\bar{q},x'). \tag{5}$$

This is also the maximum quality level supplied in the market. In addition, for this to be a stable equilibrium, the price schedule must intersect the supply schedule from above, or equivalently,

$$R_q - P_q \bar{q}_q - P_x x_q > 0. \tag{6}$$

B. *Social Welfare*

In the presence of imperfect information, even competitive markets may not provide the socially optimal price and quality levels. This can be demonstrated by defining a social welfare function, W(q), to be the sum of consumer and producer surplus:

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[4] This assumption is relaxed in Section IV.

[5] As pointed out by Leland, in the event consumers are risk adverse to quality variations, a certainty equivalent measure could be used instead of average quality.

$$W = \int_0^{q'} f(q_i)\{P[q_i,F(q_i)] - P(\bar{q},x')\}\,dq_i + \int_0^{q'} f(q_i)\,\{P[\bar{q},x'] - R(q_i)\}\,dq_i, \qquad (7)$$

where consumer surplus is the difference between the value of the good to consumers and the price paid, weighted by the quantity supplied at each q_i, and where producer surplus is the difference between the price received by suppliers and the opportunity cost, weighted by the quantity supplied at each q_i. This expression simplifies to:

$$W = \int_0^{q'} f(q_i)\{P[q_i,F(q_i)] - R(q_i)\}\,dq_i, \qquad (8)$$

where upon integration the first term is simply the gross consumer benefit and the second term is the total opportunity cost of providing the good.

The formulation of social welfare in (8) differs from that employed by Leland in two ways: First, this formulation is more general in that it does not assume quantity is distributed uniformly across the quality spectrum. Second, Leland defined gross consumer benefit to be

$$\int_0^{x'} P(\bar{q},x_i)\,dx_i,$$

or equivalently, the price willing to be paid for a unit of the good <u>with quality equal to the average</u>, $\bar{q}$, summed across all units consumed. However, the measure of benefit in consuming a unit of output should be invariant to characteristics of the market in which the unit is consumed. In this case, the market characteristic is imperfect information as to the quality of each unit consumed. The correct representation of consumer benefit is the price willing to be paid for each unit, <u>given the actual quality level of that unit</u>, summed across all units consumed.[6] While Leland's measure may be a reasonable approximation of the gross consumer benefit,[7] it is nevertheless inexact and unnecesssary. Moreover, the approximation becomes problematic when its derivative is employed to mathematically characterize the socially optimal outcome.[8] To the extent that the

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[6] In the context of Leland's model, the expression would be:

$$\int_0^{x'} P[q(x_i),x_i]\,dx_i.$$

[7] Indeed, it is exact if the price function is linear in q.

[8] For example, while a linear function may be a reasonable approximation for a quadratic over some range of values, this does not imply that its derivative (a constant) would be a reasonable approximation for the derivative of the quadratic (a linear function) over the same range.

conclusions of this analysis differ from those of Leland's paper, these differences can for the most part be traced to this juncture.

Upon differentiating (8) with respect to the marginal quality level, q', one obtains:

$$W_q = f(q')[P(q',x') - R(q')] \tag{9}$$

where $x' = F(q')$. Assuming W to be a unimodal function of q, the sign of (9) can be used for any given market outcome to determine whether quality is supplied at a level greater than or less than the social optimum.

Of particular interest is the competitive solution characterized by equation (5). Substituting this into the expression W_q, one finds:

$$W_q^c = f(q')[P(q',x') - P(\bar{q},x')] > 0 \tag{10}$$

Since price is assumed to be an increasing function of q, W_q is positive when evaluated at the competitive market solution, implying that quality would be undersupplied. This result supports Leland's conclusion that a "lemons market" is a general phenomenon in competitive markets characterized by asymmetric information.[9]

III. Minimum Quality Standards

At this point, a minimum quality standard is introduced into the analysis. As per Leland, implementation and enforcement costs are ignored, as well as the implicit costs of foregoing potentially superior alternatives to such standards. Instead, the analysis identifies those situations where minimum quality standards may otherwise improve social welfare.

Functionally, a minimum quality standard is treated as setting a level of quality, L, below which supply is eliminated. That is, product can be supplied only over the interval [L, q']. This has the effect of reducing quantity supplied of lower quality product, thereby raising average quality and hence market price. As price rises, the marginal (i.e., maximum) quality level rises as well, thereby increasing the supply of higher quality product. Theoretically, then,

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[9] By construction, quantity can only increase as higher quality products are supplied in the market, i.e., quality and quantity vary directly. Therefore, for a social optimum denoted $[q^*,x^*]$, if $q^c<q^*$, then $x^c<x^*$, i.e., quantity is under-supplied in the competitive outcome as well. However, for a given $q^c<q^*$, quantity may be over- or under-supplied. That is, it is possible for there to be too much low quality product supplied, even though that quantity level may be less than what would be desired at the socially optimal quality level.

a minimum quality standard will raise average quality while increasing or decreasing quantity supplied.[10]

If a minimum quality standard of L is imposed, then the preceding analysis is changed in the following ways. First, the average quality level over the interval [L,q'] becomes

$$\bar{q}^L = \frac{\int_L^{q'} f(q_i)q_i \, dq_i}{\int_L^{q'} f(q_i) \, dq_i} . \tag{11}$$

Second, the total quantity supplied, x', is given by

$$x' = \int_L^{q'} f(q_i) \, dq_i = F(q') - F(L). \tag{12}$$

Finally, equilibrium is characterized by the condition,

$$P(\bar{q},x') = R(q'), \tag{13}$$

where once again to ensure a stable equilibrium:

$$R_q(q') - P_q(\bar{q},x') \, \bar{q}_q - P_x(\bar{q},x')x_q > 0, \tag{14}$$

where $\bar{q}_q = f(q')[q'-\bar{q}]/x'$.

Social welfare is defined as

$$W = \int_L^{q'} f(q_i)\{P[q_i,F(q_i)-F(L)] - R(q_i)\} \, dq_i \tag{15}$$

and its derivative with respect to L can be found:

$$\begin{aligned} W_L = & - f(L)\int_L^{q'} f(q_i)\{P_x[q_i,F(q_i)-F(L)]\} \, dq_i \\ & + f(q')[P(q',x') - R(q')] \, q_L \\ & - f(L)[P(L,0) - R(L)] . \end{aligned} \tag{16}$$

Since $x' = F(q') - F(L)$, $x_L = f(q')q_L - f(L)$, and

$$\begin{aligned} W_L = & - f(L)\int_L^{q'} f(q_i)\{P_x[q_i,F(q_i)-F(L)]\} \, dq_i \\ & + [P(q',x') - R(q')] \, x_L \\ & + f(L)\{[P(q',x')-P(L,0)] - [R(q')-R(L)]\} . \end{aligned} \tag{17}$$

The derivative of q' with respect to L can be found by differentiating the equilibrium condition (13) with respect to L, yielding:

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[10] For example, a minimum quality standard may increase total quantity supplied in a market if the frequency distribution of supply is relatively more "dense" at high levels of quality.

$$q_L = \frac{P_q(\bar{q},x')\,\bar{q}_L - P_x(\bar{q},x')f(L)}{R_q(q') - P_q(\bar{q},x')\,\bar{q}_q - P_x(\bar{q},x')f(q')}, \quad (18)$$

where $\bar{q}_L = f(L)[\bar{q} - L]/x'$ and $\bar{q}_q$ is defined as before. Note that the denominator of (18) is positive due to the stability condition (14). The numerator is also positive since $P_x<0$ and $P_q>0$. Hence, quality can be expected to increase as a minimum quality standard is increased. The same cannot be concluded for quantity supplied:

$$\begin{aligned} x_L &= f(q)\,q_L - f(L) \\ &= \frac{f(L)\{P_q(\bar{q},x')[f(q')(q'-L)/x'] - R_q(q')\}}{R_q(q') - P_q(\bar{q},x')\,\bar{q}_q - P_x(\bar{q},x')f(q')}. \quad (19) \end{aligned}$$

While the denominator is positive, the numerator is indeterminate, depending on the relative magnitudes of quality's marginal demand valuation and marginal opportunity cost. Presumably, as L increases, P_q would fall eventually, causing the numerator to become negative.

The sign of W_L serves as an indicator of the desirability of increasing or decreasing some minimum quality standard. For example, if its value is negative at $L = 0$, then a minimum quality standard would generally decrease social welfare.[11] Evaluating W_L at $L = 0$:

$$\begin{aligned} W_L\Big|_{(L=0)} = &- f(0)\int_0^{q'} f(q_i)P_x[q_i,F(q_i)-F(0)]\,dq_i \\ &+ [P(q',x') - P(\bar{q}',x')]\,x_L \\ &+ f(0)\{[P(q',x')-P(0,0)] - [R(q')-R(0)]\}. \quad (20) \end{aligned}$$

The sign of (20) is indeterminate, depending among other things on the sign of x_L, i.e., the output response to a minimum quality standard. In order to simplify the analysis, denote the average marginal valuation of output over the interval $[0,q']$ to be

$$\bar{P}_x(\cdot,x') \equiv \int_0^{q'} f(q_i)P_x[q_i,F(q_i)-F(L)]\,dq_i \,/\, x'. \quad (21)$$

Then, assuming $P_{xx}\approx 0$,

$$\begin{aligned} W_L\Big|_{(L=0)} = &- f(0)\{\bar{P}_x(\cdot,x') + [P(0,x') - P(0,0)]\} \\ &+ [P(q',x') - P(\bar{q},x')]\,x_L \\ &+ f(0)\,\{[P(q',x')-P(0,0)] - [R(q')-R(0)]\} \end{aligned}$$

[11] If W(L) is a continuous concave function then this conclusion is always true.

$$\approx \quad - f(0)\, x' \{ \bar{P}_x(\cdot, x') - P_x(0,x') \}$$
$$+ \; [P(q',x') - P(\bar{q},x')]\, x_L$$
$$+ \; f(0) \{ [P(q',x') - P(0,x')] - [R(q') - R(0)] \}. \quad (22)$$

The first term's sign is determined by the relative magnitudes of the marginal valuation of quantity at q=0 and the (weighted) average of the marginal valuation of quantity over the interval [0,q']. This difference is determined in turn by P_{xq}, which can be positive or negative.[12] Indeed, the sign of W_L evaluated at L=0 is inversely related to the sign of P_{xq}.[13] In addition, a minimum quality standard will be more desirable: (1) if x_L, the response of output to a minimum quality standard, is positive and large, (2) the larger the marginal valuation of quality, (3) the smaller the marginal opportunity cost of providing quality, and (4) the smaller the marginal valuation of quantity (in absolute value).[14] Moreover, if the bracketed difference appearing in the second term is interpreted as the increment to price minus the increment to opportunity cost over the interval [0,q'], then a minimum quality standard will be more desirable if: 1) this difference is positive,[15] and 2) f(0) is large/small as this difference is positive/negative.

Important policy implications may be cited. First, the value of a minimum quality standard cannot be determined solely on the basis of the under-provision of quality in a market of this type. Indeed,

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[12] If $P_{xq}>0$, then $P_x(q_i,x') > P_x(0,x')$ for all $q_i > 0$. Hence, $\bar{P}_x(\cdot,x')-P_x(0,x')>0$, and the sign of the first term of (22) is negative.

[13] This cross-partial derivative is related to the condition encountered and discussed by Michael Spence (1975) in modeling the quality choice of a monopoly firm. An alternative but equivalent interpretation of its sign is: whether consumers' marginal valuation of quality increases (or decreases) with quantity consumed. It is this alternative interpretation that is employed by Leland in his examination of standards set by professional groups. [See Leland (1979) p. 1338.]

[14] Similarly, Leland concludes that minimum quality standards will tend to be more advantageous in markets with a) greater sensitivity to quality variations, b) low elasticity of demand, c) low marginal cost of providing quality, and d) low value placed on low-quality service. He does not identify the sign of P_{xq} as a determinant.

[15] This is consistent with the condition (for a beneficial effect of minimum quality standards) cited by Leland that a low value be placed on low-quality service.

quality can generally be <u>expected</u> to be undersupplied in competitive markets with asymmetric information (as is shown in (10)). An equally relevant criteria would be the effect of a standard on quantity. Generally, a standard would be more likely be socially beneficial if it served to increase rather than decrease quantity supplied.[16]

IV. Markets in Which Opportunity Costs Decrese with Quality

Up to this point, the opportunity cost schedule of suppliers has been assumed to vary directly with quality, i.e., $R_q>0$. However, there are some markets that appear to exhibit decreasing costs. An example commonly cited is the market for blood. At a zero price, the market consists of donors only. As the price paid rises, the quality of the blood supplied falls due primarily to a higher incidence of disease.

Leland adapts his analysis to this scenario by assuming that $R_q<0$ for all q. He concludes: (1) quality is under-supplied in the competitive market equilibrium, (2) the equilibrium quantity supplied is greater than optimal, (3) licensing will always be desirable, and (4) licensing will always result in a smaller supply.[17]

Assuming $R_q<0$, the marginal unit of quality in equilibrium, q', as characterized by (5), represents the minimal (rather than maximal) quality supplied in the market. If the maximal quality level is denoted q", then

$$R(q') = P(\bar{q},x') > R(q'') . \tag{23}$$

Social welfare can be defined as

$$W = \int_{q'}^{q''} f(q_i)\{P[q_i,F(q_i)-F(q')] - R(q_i)\}\, dq_i . \tag{24}$$

Differentiating with respect to q' yields

$$\begin{aligned} W_q = & - f(q')\int_{q'}^{q''} f(q_i)\; P_x[q_i,F(q_i)-F(q')]\, dq_i \\ & - f(q')\; [P(q',0) - R(q')] \\ = & - f(q')\int_{q'}^{q''} f(q_i)\; P_x[q_i,F(q_i)-F(q')]\, dq_i \\ & - f(q')\; [P(q',0) - P(\bar{q},x')] . \end{aligned} \tag{25}$$

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[16] It is possible however that social welfare could be improved with a standard even if the standard reduced quantity relative to both that supplied in the competive outcome and that corresponding to the social optimum.

[17] Leland (1979) pp. 1340-1.

The sign of the first term is positive, while that of the second is negative. Therefore, social welfare may increase or decrease as the marginal level of quality is increased.[18] Similarly, no determination can be made a priori as to whether quantity is under- or over-supplied.

The desirability of a minimum quality standard can be investigated in the same manner as in the previous section. That is, social welfare, defined over the interval [L, q"], is differentiated with respect to L and evaluated at $L=q'$. This yields an expression identical to (25), implying that a minimum quality standard will be desirable as quality is under- or over-supplied in a competitive equilibrium. Note that since $x' = F(q") - F(L)$, a standard necessarily will decrease quantity supplied.

The maximal level of quality forthcoming in a market may be determined in yet another manner. If R(q) is at first a decreasing and then increasing function of quality, then q' and q'' will satisfy the condition

$$R(q') = P(\bar{q}, x') = R(q") . \tag{26}$$

This is not only a reasonable assumption, it may also be more descriptive of these special markets. For example, in the market for blood, as the price increases, higher income individuals (with possibly lower incidence of disease) may be willing to sell blood.

It is easily shown that while $W_{q'}$ may be once again greater or less than zero,

$$W_{q"} = f(q") [P(q",x') - P(\bar{q},x')] > 0 , \tag{27}$$

or that q" is too low in a competitive equilibrium. The desirability of a minimum quality standard in this scenario is enhanced in two ways via its effect on the market price: By increasing price, a standard would not only increase the maximal (and average) quality supplied, it would also be less likely to decrease the quantity supplied. Nevertheless, the desirability of a standard would still be indeterminate a priori.[19]

In summary, the above analysis contradicts Leland's conclusions that quality will be under-supplied, that output always will be over-

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[18] It can be demonstrated that if $P_{xx} \approx 0$, then $P_{xq} > 0$ is a sufficient condition for $W_q < 0$.

[19] The expressions for W_L and $q_L"$ are comparable to (17) and (18). Therefore, the same market characteristics cited in the previous section can be used to identify those instances in which a minimum quality standard or licensing would be socially desirable.

supplied, and that licensing will always be desirable in markets characterized by decreasing opportunity costs.

V. Minimum Quality Standards Set by Professional Groups

Policymakers are often beset with the following dilemma: The information necessary to determine the optimal level for a minimum quality standard is vested in the professional group on whom the standard is to be imposed. However, the incentives of a professional group can be expected to be different from that of society. In such instances, it would be useful to know the direction and magnitude of any bias of the choice of a professional group of a standard away from the social optimum.

A. Producer Surplus Maximized

Assume initially that a professional group is not guided by altruism, but instead seeks to maximize (static) producer surplus. This approach was adopted by Leland. Aggregate producer surplus can be expressed as:

$$\Pi = \int_L^{q'} f(q_i) \{P[\bar{q}, F(q')-F(L)] - R(q_i)\} \, dq_i$$

$$= P(\bar{q},x')\, x' - \int_L^{q'} f(q_i)\, R(q_i)\, dq_i, \qquad (28)$$

where once again equilibrium is characterized by (13) and (14). Differentiating (28) with respect to L and equating to zero, one obtains that standard level, L_p, which maximizes producer surplus:

$$\begin{aligned}\Pi_L = \; & P_q\,[f(L)(\bar{q}-L) + f(q)(q'-\bar{q})q_L] \\ & + [P_x\, x' + P(\bar{q},x')]x_L \\ & - [f(q')R(q')q_L - f(L)R(L)] \\ \\ = \; & P_q\,[f(L)(q'-L) + (q'-\bar{q})x_L] \\ & + P_x\, x' x_L - f(L)[R(q')-R(L)] = 0. \qquad (29)\end{aligned}$$

In order to determine whether a professional group would set a standard higher or lower than the social optimum, the solution to (29) can be substituted into the expression for W_L as given in (17). Assuming W to be concave, the choice would be greater than (less than) the social optimum as W_L is negative (positive). Upon substitution:

$$W_L \Big|_{(L=L_p)} = - f(L)\int_L^{q'} f(q_i)P_x[q_i, F(q_i)-F(L)]\, dq_i$$
$$+ \ [P(q',x') - R(q')]\ x_L$$
$$+ \ f(L)\{[P(q',x')-P(L,0)] - [R(q')-R(L)]\}$$

$$= - f(L)\int_L^{q'} f(q_i)P_x[q_i, F(q_i)-F(L)]\, dq_i$$
$$+ \ [P(q',x')-R(q')]\ x_L + f(L)[P(q',x')-P(L,0)]$$
$$- \ \{P_q\ [f(L)(q'-L)+(q'-\bar{q})x_L] + P_x\ x'x_L\}. \qquad (30)$$

In general, the sign of W_L is indeterminate at $L=L_p$, which is consistent with Leland's initial conclusion that a professional group could set a quality standard that was too high or too low. However, Leland went on to argue analytically that a standard would be more likely to be set too high by a professional group.[20] In order to investigate this conclusion, it is useful to identify those factors which would contribute to a bias of L_p away from the social optimum. In order to simplify the analysis, denote the average marginal valuation of output over the interval $[L,q']$ to be

$$\bar{P}_x(\cdot,x') \equiv \int_L^{q'} f(q_i)P_x[q_i, F(q_i)-F(L)]\, dq_i \ / \ x'. \qquad (31)$$

Then, assuming $P_{xx}\approx 0$,

$$W_L \Big|_{(L=L_p)} = - f(L)x'\ \bar{P}_x(\cdot,x') + [P(q',x')-R(q')]\ x_L$$
$$+ \ f(L)\{[P(q',x')-P(L,x')] + [P(L,x')-P(L,0)]\}$$
$$- \ \{P_q\ [f(L)(q'-L) + (q'-\bar{q})\ x_L] + P_x\ x'x_L\}$$

$$\approx - f(L)x'\ \bar{P}_x(\cdot,x') + [P(q',x')-R(q')]\ x_L$$
$$+ \ f(L)\{[P(q',x')-P(L,x')] + [x'P_x(L,x')]\}$$
$$- \ \{P_q\ [f(L)(q'-L) + (q'-\bar{q})\ x_L] + P_x\ x'x_L\}$$

$$= - f(L)x'[\ \bar{P}_x(\cdot,x') - P_x(L,x')]$$
$$+ \ f(L)\{[P(q',x')-P(L,x')] - P_q\ (q'-L)\}$$
$$+ \ x_L\ \{[P(q',x')-P(\bar{q},x')] - P_q\ (q'-\bar{q})\} \qquad (32)$$

[20] Leland (1979), pp. 1338-9.

The bracketed quantities in the second and third terms of (32) relate to the signs of P_{qq} and P_{qqq}.[21] It is reasonable to expect $P_{qq} \leq 0$. If P_{qq} 0, then both terms are zero, and the incentive of a professional society to set a standard different from the social optimum is reflected entirely in the sign of the first term. If $P_{qq}<0$, then: the first term is indeterminate in sign (but will be zero if $P_{qqq} \approx 0$); and the bracketed amount in the second term will be negative.[22] Of perhaps more interest is the first term whose sign is determined by the relative magnitudes of the marginal valuation of quantity at q=L and the (weighted) average of the marginal valuation of quantity over the interval [L,q']. This difference is determined in turn by P_{xq}, which can be positive or negative.[23] Indeed, the sign of W_L evaluated at $L=L_P$ is inversely related to the sign of P_{xq}.[24]

In conclusion, no analytical support can be found for the position that a professional group would be likely to set a quality standard which is too stringent. This result should not be surprising, since the intuition underlying this position, i.e., entry deterrence, is one which cannot be captured in a static analytical framework.

B. Incumbents' Surplus Maximized

In the face of entry into a profession over time, a professional group, in pursuing its own self interest, may seek to maximize profit (or producer surplus) for its current membership rather than its future membership. While the preceding analysis adopted Leland's assumption that a professional group maximizes total producer surplus, a more

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[21] Upon dividing through by (q'-L), the first first bracketed term can be interpreted as the average rate of change of price with respect to quality over the interval [L,q'] less the instantaneous rate of change of price with respect to quality evaluated at $\bar{q}$. The second bracketed term, upon dividing through by $(q' - \bar{q})$, can be interpreted as the average rate of change in price with respect to quality over the interval $[\bar{q}, q']$ less the instantaneous rate of change evaluated at $\bar{q}$. [Note that from (28), P_q is properly evaluated at $q=\bar{q}$.]

[22] In this case, since W_L and x_L would vary inversely, a professional society would be more likely to choose a standard in excess of the optimum if the standard caused quantity supplied to increase substantially. This result is contrary to expectations.

[23] If $P_{xq}>0$, then Px will be higher for all q>L than $P_x(L,x')$. Hence, $\bar{P}_x(\cdot,x')-P_x(L,x')>0$, and the sign of the first term of (31) is negative.

[24] Note that Leland concludes that (if R(q) is convex) $P_{xq} \geq 0$ is a sufficient condition for a professional group to choose standards that are too stringent. [See Leland (1979) p. 1338.] This result is contradicted here.

appropriate approach would be to assume that a professional group maximizes incumbents' surplus over time, where a minimum quality standard is imposed only on entrants.[25]

In this scenario, opportunity costs of incumbents are unchanged by the choice of a minimum quality standard. That is, since the application of the standard is "grandfathered", incumbents face the same opportunity costs of providing the service as before. Entrants into the profession, on the other hand, are affected, causing both average quality of entrants to increase and total supply in the industry to decline (relative to the baseline timepath). Hence, a minimum quality standard affects the producer surplus of incumbent suppliers only through the price received by incumbents (and not the opportunity cost). Accordingly, in the context of the models developed above, the maximization of incumbent producer surplus would be equivalent to maximizing industry price. A professional group would thus have an added incentive in this scenario to raise quality and to restrict quantity. Hence, in an intertemporal framework, it can reasonably be concluded that a professional group would be more likely to choose a minimum quality standard which exceeded the social optimum.

VI. Variable Inputs to Quality

Up to this point, quality levels have been assumed to be fixed for individual providers. This approach is consistent with the assumption that the quality level of a provider is a function only of some factor, for example ability, which is inherently fixed. However, quality can also depend on variable factors, i.e., activities such as education which serve to enhance the quality productivity of the fixed factor. In a competitive market where quality is unobservable to consumers, suppliers may have insufficient incentive to invest in such quality enhancing activities. An individual supplier who chooses to invest in such activities so as to raise his quality level could not subsequently command a higher price for his product or service.[26] This section examines variable inputs to quality, i.e., quality enhancing activities, that are often the target of minimum quality standards.

When minimum quality standards are applied to the product or service itself, it is termed "output regulation". It is common in situations of asymmetric information, however, for quality to be

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[25] Alternatively, the standard may be effective in deterring entry if it imposes a differential cost on incumbents vis a vis entrants.

[26] One exception to this involves market situations in which such activities could be observed by consumers, thereby serving as a market signal as to the expected quality of the product or service. See Spence [1973].

unobservable, or observable only at a significant cost. For this reason, minimum quality standards often take the form of "input regulation" by establishing limits on the inputs which go into the product or service. For example, a building code may specify the type of cement or the gauge of electrical wire used in constructing a residence. Occupational licensing that establishes a minimum education requirement can be considered to be a form of input regulation.[27] This ignores the fact that while education may enhance the productivity of ability, it may also serves as a screening mechanism to ensure that a potential supplier has an adequate combination of the necessary attributes (i.e., inputs such as ability, education, motivation, discipline) to provide a product of some minimum quality level. In this sense, occupational licensing based on education may be alternatively considered as either "composite input regulation" or "prospective output regulation".

The scope of this section is restricted to market situations in which there is asymmetric information as to quality, as well as insufficient seller-specific information for reputation-building or market signalling that could otherwise bring about efficient market solutions.

A. *Quality Enhancing Activities Without Screening*

Consider first the case where quality is a function of two variables: (1) a fixed factor, a, which is distributed uniformly over the interval [0,1], and which corresponds to a (fixed) attribute such as ability; and (2) a variable factor, e, corresponding to some quality enhancing activity such as education. In addition, assume an opportunity cost function R(a), $R_a>0$, and a cost function, C(e), $C_e>0$. As before, let market price be given by $P(\bar{q},x)$ where $\bar{q}$, the average quality, is given by

$$\bar{q} = \frac{\int_0^{a'} f(a_i)\ q(a_i,e)\ da_i}{x'}, \tag{33}$$

and the total quantity supplied is $x' = F(a')$, where a' represents the maximal/marginal unit of ability. As before, assume the output of each supplier to be one, and that suppliers are distributed over the interval [0,a'] according to f(a). Equilibrium is now defined by the equality:

$$P(\bar{q},x') = R(a') + C(e). \tag{34}$$

In a competitive market without minimum quality standards, the i^{th} supplier would choose that e_i which maximizes profit:

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[27] See Shapiro [1986] pp. 843-4.

$$\pi_i = P(\bar{q},x') - R(a_i) - C(e_i). \quad (35)$$

Since price is market-determined and not a function of e_i, the derivative of π_i with respect to e_i is negative. Hence, suppliers would choose e=0.

For any given outcome, social welfare can be expressed as

$$W = \int_0^{a'} f(a_i)\{P[q(a_i,e),F(a_i)] - R(a_i) - C(e)\}\, da_i. \quad (36)$$

where e represents some input into quality that is chosen by all suppliers. Upon differentiating this with respect to e, one gets

$$W_e = \int_0^{a'} f(a_i)\{P_q[q(a_i,e),F(a_i)]\; q_e(a_i,e) - C_e(e)\}\; da_i$$
$$+ \; a_e'\; f(a')\{P[q(a',e),F(a')] - R(a') - C(e)\} \quad (37)$$

where a_e' can be found by differentiating (34) with respect to e:

$$a_e' = \frac{P_q\; \bar{q}_e - C_e}{R_a - P_q q_a - P_x}. \quad (38)$$

and

$$\bar{q}_e = \frac{\int_0^{a'} f(a_i)\; q_e(a_i,e)\; da_i}{x'}. \quad (39)$$

Note that since the denominator of (38) is positive,[28] a_e' will be positive whenever the increase in price attributable to an increase in e (holding a' constant) exceeds the marginal cost of e for the highest ability supplier. Upon evaluating (37) at e=0, one obtains

$$W_e\Big|_{(e=0)} = \int_0^{a'} f(a_i)\{P_q[q(a_i,0),F(a_i)]\; q_e(a_i,0)$$
$$- \; C_e(0)\}\; da_i$$
$$+ \; a_e'\; f(a')\{P[q(a',0),F(a')] - R(a')\}. \quad (40)$$

While the sign of (40) is indeterminate, it is likely that the sign will be positive (i.e., too little e will be purchased) if $a_e' > 0$. Indeed, if $q_{ea} \approx 0$, then sufficient conditions for (40) to be positive are $a_e' > 0$, and $P_{qx} \leq 0$ (i.e., the marginal valuation of quality per unit

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28 In order for equilibria to be stable in terms of the variable a, the opportunity cost function must be crossed from above by the price function.

output should not increase with quantity consumed).[29] In general, a minimum quality standard is likely to be socially beneficial in a market: (1) the greater the marginal value of quality (i.e., the greater P_q), and the smaller the rate of decline in the marginal value as quality increases (i.e., the smaller the absolute value of P_{qq}); (2) the greater the marginal productivity of e in the production of quality (i.e., the greater q_e); (3) the smaller the marginal cost of e; (4) the smaller the rate of increase in opportunity cost as ability increases; (5) the greater the marginal productivity of a in the production of quality; and (6) the more dense the frequency distribution of suppliers at higher ability levels.

B. Quality Enhancing Activities With Screening

Consider next the case where a quality enhancing activity also serves as a screening device. That is, if higher ability suppliers have a lower cost of investing in the activity, then, as the required level of the activity is increased, lower ability providers will find it unprofitable to continue to supply in the market. This is perhaps a more appropriate paradigm for education than the case just considered.

The previous model is modified so that the cost of the quality enhancing activity incorporates the fixed attribute, a, as well as the quantity of the activity, e: $C(a,e)$ where $C_a<0$ and $C_e>0$. That is, the cost of the activity increases with the amount of the activity chosen, but the cost for a given level of the activity is lower for those suppliers with a high level of the fixed attribute, a. For example, it is presumably less costly in terms of time and effort for high ability individuals to complete a given level of professional training than it is for low ability individuals.

For any given level of education, e, a marginal supplier with ability a_i would be characterized by the condition

$$P(\bar{q},x') = R(a_i) + C(a_i,e) \tag{41}$$

where $R_a>0$ and $c_a<0$. For the purposes of this analysis, assume that the sum, $R(a) + C(a,e)$, is at first decreasing and then increasing in a. This assumption will generally result in two solutions to (41), denoted by a' and a'', where a'<a". That is, in equilibrium,

$$P(\bar{q},x') = R(a') + C(a',e) = R(a'') + C(a'',e). \tag{42}$$

This scenario is probably descriptive of most real world markets, in that professions typically do not include the least able and the most able potential suppliers. The very low ability potential suppliers

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[29] If $a_e'>0$, then the bracketed term in the integral of (40) is positive for $a_i=a'$. If $P_{qx}\leq 0$, then the bracketed term is positive for all a_i.

(i.e., $a_i<a'$) do not choose to enter the market because the education cost, $C(a,e)$, is, for them, relatively too high. Conversely, the very high ability individuals (i.e., $a_i>a''$) do not enter because their opportunity cost, $R(a)$, is relatively too high.

Consequently, supply is forthcoming only from those individuals with fixed attribute a_i, $a'<a_i<a''$, and x' becomes $F(a'')-F(a')$. Average quality is then

$$\bar{q} = \frac{\int_{a'}^{a''} f(a_i)\, q(a_i,e)\, da_i,}{x'}. \tag{43}$$

As before, since price received by an individual supplier is not a function of the level of e chosen by that supplier, there is no incentive for suppliers to invest in quality enhancing activities. Therefore, a competitive market equilibrium would result in $e=0$. It is useful to determine under what conditions social welfare would be improved by a minimum quality standard.

For any given level of education, social welfare can be expressed as

$$\begin{aligned} W = \int_{a'}^{a''} & f(a_i)\{P[q(a_i,e),F(a_i)-F(a')] \\ & - R(a_i) - C(a_i,e)\}\, da_i. \end{aligned} \tag{44}$$

The derivative of W with respect to e is then

$$\begin{aligned} W_e = \int_{a'}^{a''} & f(a_i)\{P_q[q(a_i,e),F(a_i)-F(a')]\, q_e(a_i,e) \\ & - a'_e f(a')P_x(q(a_i,e),x') - C_e(a_i,e)\}\, da_i \\ & + a''_e f(a'')\{P[q(a'',e),x']-R(a'')-C(a'',e)\} \\ & - a'_e f(a')\{P[q(a',e),0]-R(a')-C(a',e)\}. \end{aligned} \tag{45}$$

When evaluated at $e=0$,

$$\begin{aligned} W_e\Big|_{(e=0)} = \int_{a'}^{a''} & f(a_i)\{P_q[q(a_i,0),F(a_i)-F(a')]\, q_e(a_i,0) \\ & - a'_e f(a')P_x[q(a_i,0),x'] - C_e(a_i,0)\}\, da_i \\ & + a''_e f(a'')\{P[q(a'',0),x']-R(a'')-C(a'',0)\} \\ & - a'_e f(a')\{P[q(a',0),0]-R(a')-C(a',0)\}. \end{aligned} \tag{46}$$

The sign of (46) is indeterminate. As a simplification, assume that $P_{xx}\approx 0$ and denote the average marginal valuation of output over the interval $[q',q'']$ as

$$\bar{P}_x(\cdot,x') \;\equiv\; \int_{a'}^{a''} f(a_i)P_x[q(a_i,0),x']\, da_i \;/\; x'. \qquad (47)$$

Then, upon substitution from equations (42) and (47),

$$\begin{aligned} W_e\Big|_{(e=0)} = & \int_{a'}^{a''} f(a_i)\{P_q[q(a_i,0),F(a_i)-F(a')]\; q_e(a_i,0) \\ & \quad - C_e(a_i,0)\}\, da_i \; - \; a'f(a')x' \; \bar{P}_x(\cdot,x') \\ & + a_e'' f(a'')\{P[q(a'',0),x']-P(\bar{q},x')\} \\ & - a_e' f(a')\{P[q(a',0),x']-P(\bar{q},x')\} \\ & + a'f(a')\{P[q(a',0),x']-P[q(a',0),0]\}. \qquad (48) \end{aligned}$$

If $P_{xx}\approx 0$, then

$$\begin{aligned} W_e\Big|_{(e=0)} \approx & \int_{a'}^{a''} f(a_i)\{P_q[q(a_i,0),F(a_i)-F(a')]\; q_e(a_i,0) \\ & \qquad - C_e(a_i,0)\}\, da_i \\ & + a_e''\, f(a'')\{P[q(a'',0),x']-P(\bar{q},x')\} \\ & + a_e'\, f(a')\{P(\bar{q},x')-P[q(a',0),x']\} \\ & - a'f(a')x'\{\, \bar{P}_x(\cdot,x')-P_x[q(a',0),x']\}. \qquad (49) \end{aligned}$$

The first term of (49) is the valuation of the increased quality attributable to the marginal increase in e, less the marginal cost of e, integrated across all a_i; note that this term corresponds to that obtained in the previous case in which the quality enhancing activity involved no screening. Since $P_q>0$, the second and third terms are positive or negative depending on whether $a_e''\gtrless 0$ and $a_e'\gtrless 0$, respectively. Since a supplier with $a_i=a'$ will be most disadvantaged by an increase in e from e=0, a_e' can reasonably be expected to be positive. For a_e'' to be positive, the increase in price (as all suppliers invest in the marginal unit of e) received by the supplier with $a_i=a''$ must be greater than the cost of e. Hence, it cannot be presumed that $a_e''>0$. The fourth term is positive or negative as $P_{xq}\gtrless 0$. Accordingly, sufficient conditions for a minimum quality standard to be socially beneficial are: (1) the value of the incremental increase in quality arising from a marginal increase in e is greater than the marginal cost of e for all suppliers, (2) the minimum quality standard causes higher ability suppliers to enter the market, and (3) $P_{xq}\geq 0$.

In general, a minimum quality standard is more likely to be socially beneficial in a market with asymmetric information: (1) the greater the marginal value of quality (i.e., the greater P_q), and the smaller the rate of decline in the marginal value as quality increases (i.e., the smaller the absolute value of P_{qq}; (2) the greater the marginal productivity of e in the production of quality (i.e., the greater q_e); (3) the smaller the marginal cost of e; (4) the greater the cost of investing in the activity for low ability suppliers (relative to that for high ability suppliers); (5) the smaller the rate of increase in opportunity cost as ability increases; (6) if $P_{xq} \geq 0$, and (7) the more dense the frequency distribution of suppliers at higher ability levels (relative to that at lower ability levels).

VII. Conclusion

This paper has expanded on the analytical models of Akerlof and Leland in order to examine the benefits of minimum quality standards in markets characterized by asymmetric information as to product quality. The principal conclusions are:

(1) Competitive equilibria in these markets are generally characterized by insufficient quality and output, the hallmarks of a lemons market.

(2) Minimum quality standards may or may not be desirable in such markets. Relevant demand and supply conditions are identified. Contrary to Leland, a decreasing opportunity cost schedule for quality does not necessarily imply the social desirability of licensing or minimum quality standards.

(3) In the static analytical framework employed by Leland, no support can be found for Leland's conclusion that a professional group would be likely to set standards that are too stringent. On the other hand, support can be found for this position within an intertemporal framework which incorporates entry and grandfathering of standards.

(4) Minimum quality standards defined on quality-enhancing activities (such as education) may or may not be socially desirable. This conclusion is unchanged even when the activity provides screening of suppliers as to innate ability. Relevant demand and supply conditions are identified.

Perhaps the most important policy implication arising from this analysis is that it is inappropriate to infer the desirability of a minimum quality standard (solely) from the observation of under-provision of quality in a market. A standard's effect on both quantity and quality should be considered in determining its merits.

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