FACULTY WORKING
PAPER NO. 1107

Quality in Contestable Markets: Theoretical Notes on a Historical Problem

Salim Rashid

College of Commerce and Business Administration
Bureau of Economic and Business Research
University of Illinois, Urbana-Champaign

FACULTY WORKING PAPER NO. 1107

College of Commerce and Business Administration

University of Illinois at Urbana-Champaign

January, 1985

Quality in Contestable Markets: Theoretical Notes on a Historical Problem

Salim Rashid, Associate Professor
Department of Economics

ABSTRACT

This paper attempts to combine the recent ideas on contestability with older ideas on monopolistic competition in order to analyze theoretically a question of considerable interest to economic historians: why does the quality of a good tend to deteriorate in markets with many producers?

QUALITY IN CONTESTABLE MARKETS: THEORETICAL NOTES ON A HISTORICAL PROBLEM

I. The theory of contestable markets has made notable inroads into the traditional way of looking at markets with only a few producers but its relationship to the theory of monopolistic competition has been largely overlooked.[1] This omission is due mainly to the assumption of a homogeneous output in the contestable markets literature. In this article I would like to explore the link between having a multiplicity of producers and the quality of goods provided in the market.[2] We would like to believe that competition among producers (which is not assumed to be perfect competition) suffices to produce those qualities most desired by consumers. Historically, however, complaints about the quality of goods supplied by contestable markets have been legion as I shall illustrate by some examples in Section II. Is the failure of quality to be maintained simply a reflection of the diversity of consumer tastes or do we have a failure of market organization?

It is curious to note that Adam Smith appears to have supported the office of the aulnager, or sealer of cloth, in England because one would have assumed that Smith found competition to be a sufficient guarantee of quality. After explicitly noting the desirability of having a central authority certify the quality and goodness of coin, Smith goes on to compare such actions with the office of the aulnage, thereby giving his approval of the latter.[3]

> To prevent abuses, to facilitate exchanges, and thereby to encourage all sorts of industry and commerce, it has been found necessary, in all countries that have made any considerable advances

> towards improvement, to affix a publick stamp upon certain quantities of such particular metals, as were in those countries commonly made use of to purchase goods. Hence the origin of coined money, and of those publick offices called mints; institutions exactly of the same nature with those of the aulnagers and stampmasters of woollen and linen cloth. All of them are equally meant to ascertain, by means of a publick stamp, the quantity and uniform goodness of those different commodities when brought to market.

If we follow through the logic of one of the features of a contestable market emphasized by Baumol then it will be seen that the Smithian view is perhaps not so strange. Baumol emphasizes the fact that an incumbent is always vulnerable to hit-and-run entry if he ever tries to exert his potential monopoly power.

> The crucial feature of a contestable market is its vulnerability to hit-and-run entry. Even a very transient profit opportunity need not be neglected by a potential entrant, for he can go in, and, before prices change, collect his gains and then depart without cost, should the climate grow hostile.

This proposition is certainly true as far as it goes but it can in fact be taken much farther. If there are no sunk costs and entry is free then who is to tell the incumbent from the entrant? Why is not the entire industry composed of transients? And if the industry is composed of a large number of transients, why should they care bout how the consumers regard the quality of their product?

Section II considers the evidence for quality variations in a number of instances--wool in England, linen in Ireland, silk in China and milk in Bangladesh. Section III turns to the problems involved in modelling such situations, presents a formal model and notes that a multiplicity of producers appears to be no guarantee of a uniform

quality. Section IV provides some additional historical evidence and concluding remarks.

II. In reading about the fortunes of the English cloth industry one is struck by the continued repetition of complaints about quality. This widespread belief led to the passage of many laws whose intent was to secure the uniformly good quality of woolen cloth, the primary English export of the three centuries prior to the Industrial Revolution. In describing the structure of the woolen industry in the seventeenth century, an economic historian comes close to describing what is now called "contestability."[5]

> Outside a few special trades, the individual entrepreneur had a preponderance of his investment in the form of circulating captial and could therefore withdraw from participation in his activity far more easily than his nineteenth-century counterpart--much of whose capital was immobilized in fixed items of investment... [A] sudden expansion in output would be secured less by a change in organization or techniques than by an increase in employment and a multiplication of units of production. Conversely, a fall in demand would quickly put pressure on wages and employment. In these circumstances, one marked feature of society...was a considerable horizontal and even vertical mobility of capital, entreprenurial skill and labour.

It is curious to note that similar complaints arise in the case of Irish linen in the nineteenth century.[6]

Cloth production appears to be peculiarly prone to such problems for we find the uneven quality of raw silk to be an issue in nineteenth century China. Mechanization demands a homogenous input and American buyers repeatedly complained about the quality of silk being sent to their plants. Self-interest alone should have dictated that a reform of the Chinese silk industry take place. None did however and the link between the multiplicity of small producers is noted by modern commentators.[7]

> The Chinese were never noted for a capacity to produce a large supplies of any commodity to a uniform quality, and in silk production, which necessarily takes place in small units, the problem was especially troublesome.

Henry Accum created a considerable stir in 1820 with his Treatise on Adulterations of Food in which he showed the widespread adulteration of both foods and drugs in England. Accum was unable to obtain any legislative help however and it was not until the 1870's that samples were taken and analyzed, when it was found that, between 1876 and 1886, a minimum of 11.9 percent and a maximum of 19.2 percent of such articles were adulterated.[8] The difficulty of verifying the quality of foods without microscopes however makes this an unsatisfactory example for my purposes. In order to separate out the affects of consumer tastes and knowledge from those of industrial structure it is necessary to find a commodity whose quality is readily ascertainable by consumers and where some "objective" determination of the most desirable quality can be arrived at.

Milk is an excellent commodity for such a purpose. Most consumers are familiar with it and the purity, in terms of fat content, is readily ascertainable by taste. It is curious that many countries have difficulty in readily providing pure milk. In the Baltimore of the 1920's, when milk distribution was locally organized, pure milk was something of a rarity. A student of the industry describes conditions as follows:[9]

> In the days before bottling plants and refrigerated milk trucks, entry into the market was easy, and hundreds of milk dealers and farmers fought for a share in that market. In Baltimore, as in other

> cities, fierce competition between the many suppliers meant that cutting prices was more important than improving milk quality.

Once again, the connection between a multiplicity of small producers and quality will be noted.

In Bangladesh today, pure milk is hard to find. Several hundred peasants supply milk to the capital city, Dhaka, from surrounding villages. The only fixed capital, cows, are readily salable in an active market. So entry and exit are both easy. And adulteration is widespread. In 1978 a local newspaper went so far as to publish photographs showing peasants from the villages stopping on the wayside in order to adulterate their milk. Not only was the water added in public but it was water from a local irrigation canal! A variant of this situation is reported in India where rice is sold mixed with pebbles. So great is the speculation in this line that small hawkers can be found next to the large rice sellers whose only task is to provide them with pebbles! We need a model that will rationalize the existence of impure equilibria in contestable markets with many sellers.

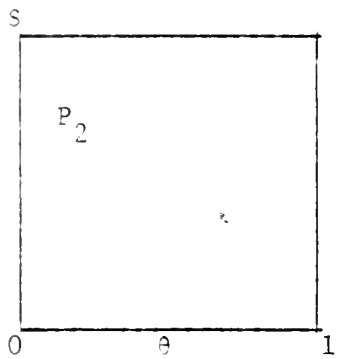
III. It was noted earlier that the curious feature about the adulteration of milk is that the producer of diluted milk provides no service that cannot be better provided by the consumer, and at zero cost. If milk is best taken diluted, then why not dilute it at home where one has control over both the quality and quantity of water to be added? Why risk drinking canal water when the alternative is so simply available? On the assumption that milk is adulterated solely with clean water, an assumption least favorable to my thesis, the cost function for milk of qulaity θ is given by $C(\theta) = \theta$. $0 \leq \theta \leq 1$. Here $\theta = 1$ denotes a gallon of pure milk whose cost is normalized at unity. Since the adulterant, water, is free, the cost of adulterated milk of quality θ is θ, where θ can also be read as the proportion of pure milk in a gallon of "milk" supplied for sale. As every consumer can be assumed to have access to water as clean as that available to the dairy farmer, the only rational price a customer will pay for a gallon of milk of quality θ is θ, where the price of a gallon of pure milk is set equal to its cost of unity. In order to see where the difficulties arise, let us look at the simplest model in which a producer produces one, and only one, "gallon" of milk. The only choice variable is quality. If $p(\theta)$ denotes the price paid for a good of quality θ and $C(\theta)$ the corresponding cost, the profit of the producer is given by

$$\pi = p(\theta) - C(\theta)$$

with first-order conditions for an interior maximum of

$$p_1 - c_1 = 0$$

$$p_{11} - c_{11} < 0$$



In order to ensure an interior equilibrium, we must have $p_{11} < 0$. The shape of the demand curve for quality is thus of central importance in deciding the existence of an equilibrium. It was just argued in the case of milk that the only "rational" shapes of such curves would be convex or, at best, linear. How can the curves turn concave? Something must be done to modify the dependence of pirce soley on quality. The most natural modification is to assume that the demand curve depends not only on the quality of milk actually offered for sale, but also on the average quality available in the market. The typical consumer is now supposed to react as follows to milk of 90 percent purity. "If 100% pure milk is readily available, I will not touch this stuff. However, if I can expect to get only 85% pure milk in the maret this milk is worth almost a whole dollar to me." For high levels of (average) market purity the demand curve will be convex but for lower levels of purity the curve can now be concave.[10] The two features noted above, namely, (a) the dependence of price on

average quality available and (b) the concavity of the "demand" relation for some values of θ, will be of crucial importance for the model being developed.

The producers problem is now

$$\max\ p(\theta,\nu) - C(\theta)$$

where ν is the average quality available.

The assumptions already made about the milk market enable us to be a little more precise about profits. Once a gallon of milk is produced, all costs have been incurred. The actual choice of quality is thus independent of production. If one decides to sell milk with 50 percent water then one has doubled the amount of milk for sale. For this problem therefore the function to be maximized is revenue, or, $\pi = \frac{p(\theta,\nu)}{\theta}$. Maximizing with respect to θ,

$$\frac{d\pi}{d\theta} = \frac{\theta p_1 - p}{\theta^2} = 0 \text{ or } \theta = \frac{p}{p_{11}} \tag{1}$$

$$\frac{d^2\pi}{d\theta^2} = \frac{\theta^2 p_{11} - 2p_1\theta + 2p}{\theta^3} < 0 \text{ or } p_{11} < 0 \tag{2}$$

The concavity of $p(\theta,\nu)$ with respect to θ, a condition whose plausibility was argued earlier, is thus sufficient for an interior maximum. If we make the "heroic" Chamberlinian assumption of "identical" cost and demand conditions across firms then we will have industry equilibrium with $\theta = \nu$, a condition to be explored below. Otherwise, a diversity of milk quality will appear in the market. The conditions of this problem, have been so chosen however as to suggest that a

failure of some kind, either on the part of the consumer or that of the producer, exists whenever impure milk continues to be offered on the market. Why would a consumer ever want to have his milk supply adulterated by someone else?

To do comparative statics, differentiate (1) with respect to ν to get

$$\frac{d\theta}{d\nu} = \frac{p_{12}(1-\theta)}{p_1 + p_{11}(\theta-1)}$$

The concavity of $p(\theta,\nu)$ serves to make the denominator positive and so the sign of the expression depends upon p_{12}.

Regardless of the sign of $\frac{d\theta}{d\nu}$, there are two circumstances in which we can be sure that individual producer choices will immediately lead to market equilibria.

(a) if $p_{12} = 0$, then producers do not care what average quality is; as a result, their choice will necessarily become the average.

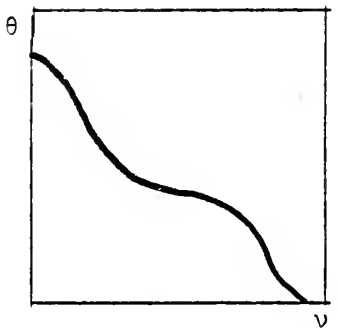
(b) if $p_{12} = C_{11} - p_{11}$, so that $\frac{d\theta}{d\nu} = 1$, always, then since $\theta = \nu$ at both the endpoints of 0 and 1, θ must equal ν everywhere on the unit interval.

In order to sign p_{12} let us consider the two simplest functional forms that represent the dependence of p on θ and ν

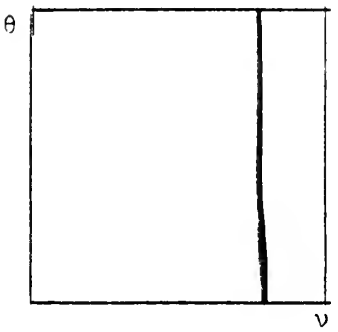
A. $p = \alpha + \beta\frac{\theta}{\nu} + \eta\theta$, $\beta,\eta > 0$

B. $p = \alpha' + \beta'(\theta - \nu)^{\gamma} + \eta'\theta$, $\beta',\eta' > 0$, $\gamma = 1$, 2 or 3.

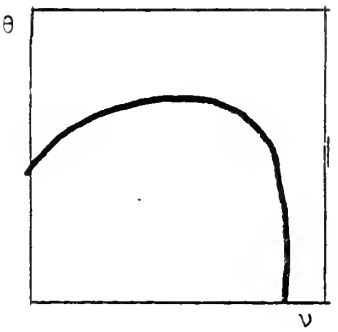
In A., $p_{12} < 0$ and in B., $p_{12} = 0$ for $\gamma = 1$, $p_{12} < 0$ for $\gamma = 2$, and $p_{12} \gtrless 0$ for $\gamma = 3$ depending on whether $\theta \gtrless \nu$. The diagrams below plot the various shapes for $\theta(\nu)$.



A.



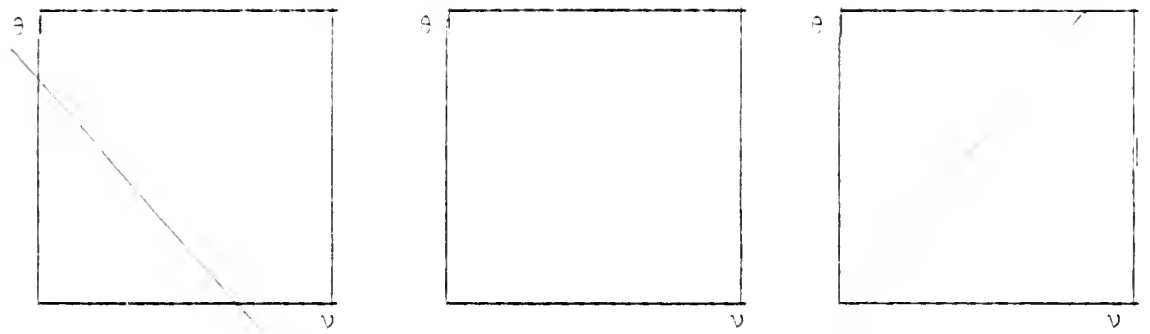
B. $\gamma = 0$



B. $\gamma = 3$

also B. $\gamma = 2$

In all cases, it will be seen that the slope of $\frac{d\theta}{d\nu}$ necessitates that $\theta(\nu)$ intersect the 45° line to provide us with a market equilibrium. Furthermore, the same restrictions on the slopes imply that the interior equilibrium will be unique. It will be seen that for an individual producer to sell pure milk regardless of the quality being sold in the market would require, as a necessary condition, that $p_{12} = 0$, and that this is not the only plausible specification of demand. The Appendix extends this model to the case where quantity and quality can be chosen by the producer and it is shown that there is still a presumption that impure equilibria will occur.[11]



A. B. $\gamma = 0$ B. $\gamma = 3$

also B. $\gamma = 2$

In all cases, it will be seen that the slope of $\frac{d\theta}{d\nu}$ necessitates that $\theta(\nu)$ intersect the 45° line to provide us with a market equilibrium. Furthermore, the same restrictions on the slopes imply that the interior equilibrium will be unique. It will be seen that for an individual producer to sell pure milk regardless of the quality being sold in the market would require, as a necessary condition, that $p_{12} = 0$, and that this is not the only plausible specification of demand. The Appendix extends this model to the case where quantity and quality can be chosen by the producer and it is shown that there is still a presumption that impure equilibria will occur.[11]

IV. Libertarian readers have asked me how I could be sure that the public did not really want diluted milk. The suggestion has moderate plausibility in some cases, but one can hardly believe that consumers would not prefer to dilute the milk themselves--this would not only give them control over the extent of dilution but also ensure that the water being added was clean. And how does one rationalize all the pebbles in the rice along libertarian lines?[14] Whatever the consumer saves in buying a cheaper product he more than pays for through a weakened constitution and higher medical bills.

Akerlof had concluded from his pioneering study that some mechanism was necessary to supplement the usual competitive framework in order to avoid problems such as the non-existence of a market for used cars. Geoffrey Heal (1976) suggested in a comment on Akerlof's article that the problem was considerably mitigated if we assumed the traders to deal repeatedly with each other, in which case the incentive to "cheat" would be considerably diminished. Akerlof pointed out in his reply that there was no institution in the market to ensure that buyers and sellers would frequently meet each other; furthermore, Heal's result was unstable in the sense that "bad" behavior on the part of even one trader could lead everyone to revert to providing lower quality products.

The commonest "solution" for quality deterioration is, of course, to set minimum standards. Yet another is to make the seller liable for the quality of his product, i.e., to replace the usual rule of _caveat emptor_ by _caveat venditor_. Hayne Leland (1979) has considered the former problem and concluded that minimum quality standards will

be more advantageous, ceteris paribus, under any of the following four circumstances (a) greater sensitivity to quality variations, (b) low elasticity of demand, (c) low marginal cost of providing quality, (d) low value placed on low-quality service. Leland also concludes that if a professional group is to set the minimal quality then there will be a tendency to set this minimum higher than is socially optimal.

The solution proposed by Heal does not require continual government (or professional) action once the appropriate institution is set up while the proposal to have minimum quality standards obviously requires monitoring. Unfortunately, as long as we continue with the assumptions of monopolistic competition, requiring many small producers and contestability, requiring easy entry and exit, it is hard to think of any mechanism that will ensure repeated meetings of buyer and seller at low cost.

The difficulties with government or professional regulation are just as great if not greater. Not only is it possible for the quality of individual producers to move in a direction opposite to that of the average, the presumption that honest enforcement can be attained is a questionable one. There is no good reason why actions which are profitable for private dairy farmers are not also profitable for state owned dairy farms. The same system that permits quality deterioration to occur in private firms will generally be powerless to prevent its occurrence within a bureaucracy.

If the historical evidence is any guide, it will appear that neither of the above approaches is quite feasible. Where quality

control has been effectively exercised, it has occurred by enlarging the effective unit of production and by having a self-interested party, the buyer, assume responsibility. The failure of attempts to effectively regulate the quality of woolen cloth is well-known to economic historians; nonetheless, it is true that the quality of worsted cloth was effectively regulated in the late eighteenth century by the Worsted Committee, an employers organization. Herbert Heaton comments on the difference between the woolen and worsted industries[12]--"in the woolen a large number of small men, in the worsted a small number of big men." (The cloth halls at Leeds provided almost 3,000 stalls for the woolen industry and only 258 for the worsted.) Similarly, it is noticeable that the Chinese with their dispersed production were unable to provide quality silk while the Japanese succeeded in doing so. Once again, the organization of the industry appears to be the decisive factor. Larger units were prevalent in Japan than in China, and the State was willing to give legal sanction to desirable actions.[13]

> Despite the achievements of the foreigners in developing markets for Chinese silk and in modernising the organization of methods of silk production, the trade, as we have seen, failed in competition with the Japanese. Some reasons for this failure have already been given; but as the explanation goes to the root of Chinese commercial backwardness it may usefully be elaborated. The silk trade, for its successful organization, needed a high degree of centralisation at some points and a wide dispersion at others. The production of cocoons is necessarily a manual process and is highly suited to small-scale peasant agriculture. If, however, large quantities of uniform silk are to be provided--and uniformity is necessary for the subsequent manipulation of the silk on knitting

> frames or power looms--then there must be centralised supervision over certain processes. In Japan this supervision was provided in two ways: by the licensing of egg-producers as already described, and by the establishment of close relations between groups of silk raisers and particular filatures... Centralised control is again necessary at the port through which the silk passes for sale abroad, for at that point reliable testing and conditioning arrangements must be set up. These conditions for the successful conduct of the silk trade could not be satisfied in China. [emphasis added] .

The milk industry of countries like Denmark achieved a quality product in the nineteenth century for two reasons: first, export requirements made it desirable (the example of the Chinese silk industry tells us that this alone is not enough); secondly, the dairy industry was organized in cooperatives who also took charge of milk-processing plants. In Baltimore the effective enforcement of laws served to increase the capital requirements, restrict freedom of entry (and exit!) and change the transient nature of many producers. Indeed, it is not clear whether any of the large U.S. cities were provided with uniformly pure milk until large-scale production and distribution took charge.

The question of quality is one that has been generally ignored by economists for over 200 years. Prior to Adam Smith, it was an issue of some prominence; after 1776 however the emphasis became increasingly one of competition as the guarantor of quality output. With the exception of Charles Babbage, no economist appears to have considered this a serious issue until Edward Chamberlin focussed upon a quite different facet, product differentiation. The main thesis of this paper is that quality has a definite tendency to deteriorate in markets with many small producers and easy entry; the most effective

check to this deterioration is the increase of irrevocable fixed assets. While the conclusion seems to bear a flag for big business it should not appear so on a little reflection. When significant amounts of money are invested the businessman tells us that he plans to stay for some time to come. In the long run, the only way to stay is by pleasing customers. This requires providing them with the goods they really want and this long-term dependence of producers upon consumers is perhaps the most effective guarantee of quality.

Footnotes

[1]See Baumol (1982) and the references therein as well as the subsequent exchange with some critics (1983).

[2]While a variety of models exist dealing with quality none bear directly on the problem at hand. Dixit (1979), Dixit-Stiglitz (1977) or Spence (1976) do not deal adequately with the nature of the "different" commodities marketed. Lancaster (1975) and Leland (1977) deal solely with questions of optimality. Rosen's (1974) model is similar to mine but the thrust of his analysis is different. The spirit of Akerlof's (1970) paper is closest to my aims. However, there is no uncertainty about quality in the model to be developed in Section III.

[3]Smith (1976), 40.

[4]Baumol (1982), 4.

[5]Supple (1959), 9.

[6]A brief state of the debate concerning the sealing of brown linens... (Dublin: P. Wilson, 1763).

[7]Allen and Donnithorne (1954), 62.

[8]Stieb (1966), 120.

[9]Wessel (1984).

[10]The change of the demand relation from convex to concave suggests that the model has some curious dynamic properties, which I intend to explore subsequently. As the focus of this paper is entirely on comparative statics, I have not entered into issues of dynamics.

[11]If we make the assumption that $\pi(\theta,\nu)$ is linear in θ and continuous in ν, it is possible to show that a Nash-Equilibrium involving values of θ equal to 0 or 1 does exist. In view of the absence of any institutional mechanism which will push us from an equilibria involving $0 < \theta < 1$ to one where $\theta = 0$ or 1, such a result must be a curiosity. For a proof see S. Rashid, "Equilibrium Points of Nonatomic Games: Asymptotic Results," Economic Letters.

[12]Heaton (1920), 297.

[13]Allen and Donnithorne (1952), 68.

The research for this paper was begun with a Haney grant from Dartmouth College and continued with a grant from the Bureau of Business and Economic Research at the University of Illinois. Earlier versions have been presented at Purdue University and the University of

Illinois. I am grateful to the participants at these seminars and especially to Jeremy Atack, Fred Gottheil, Larry Neil and Peter Schran for their helpful comments. Special thanks are due to Professor W. J. Baumol for his comments.

References

Akerlof, G., "The Market of Lemons," Quarterly Journal of Economics (1970), 488-500.

Allen, G. C., and Audrey Donnithorne, Western Enterprise in Far Eastern Economic Development (London: Allen and Unwin, 1954).

Baumol, W. J., "Contestable Markets: An Uprising in the Theory of Industry Structure," American Economic Review (March 1982), 72, 1, pp. 1-15.

Baumol, W. J., J. C. Panzar and R. D. Willig, "Reply," American Economic Review (June 1983), 491-496.

Clemenz, G., "A Note on the Lemons Principle and Equilibria in a Market with Asymmetrical Information," Zeitschrift für Nationalökomie (1979), 377-350.

Darby, M., and E. Karni, "Free Competition and the Optimal Amount of Fraud," Journal of Law and Economics (1973), 67-88.

Dixit, A., "Quality and Quantity Competition," Review of Economic Studies (1979), 587-599.

Epple, D. and A. Raviv, "Product Safety: Liability Rules, Market Structure and Imperfect Information," American Economic Review (1978), 80-95.

Heal, G., "Do Bad Products Drive out Good," Quarterly Journal of Economics (1976), 499-503.

Heaton, H., The Yorkshire Woolen and Worsted Industries (Oxford 1920).

Lancaster, K., "Socially Optimal Product Differentiation," American Economic Review (1975), 567-585.

Leland, H., "Quality Choice and Competition," American Economic Review (1977), 127-137.

Leland, H., "Quacks, Lemons and Licensing: A Theory of Minimum Quality Standards," Journal of Political Economy (1979), 1328-1346.

Rosen, S., "Hedonic Prices and Implicit Markets: Product Differentiation in Pure Competition," Journal of Political Economy (1974), 34-55.

Schwartz, M., and R. J. Reynolds, "Contestable Markets: An Uprising in the Theory of Industrial Structure: Comment," American Economic Review (June 1983) 488-490.

Sheshenski, E., "Price, Quality and Quantity Regulation in Monopoly Situations," Economica (1976), 127-138.

Smallwood, D. E., and J. Conlisk, "Product Quality in Markets where Consumers are Imperfectly Informed," Quarterly Journal of Economics (1979), 1-24.

Smith, Adam, An Inquiry into the Nature and Causes of the Wealth of Nations ed. R. M. Campbell and A. S. Skinner (Oxford 1976), First edition 1776.

Spence, M., "Product Selection, Fixed Costs and Monopolistic Competition," Review of Economics (1976), 217-237.

Spence, M., "Monopoly, Quality and Regulation," The Bell Journal of Economics (1975), 417-429.

Spence, M., and B. Owen, "Television Programming, Monopolistic Competition and Welfare," Quarterly Journal of Economics (1977).

Spence, M., "Consumer Misperceptions, Product Failure and Producer Liability," Review of Economic Studies (1977), 561-572.

Stewart, M. B., "Quality Adjustments in a Market with Imperfect Information and Probabilistic Demand," Zeitschrift für Nationalökonomies (1979), 323-335.

Stieb, E. W., Drug Adulteration (Madison 1966).

Supple, B., Commercial Crisis and Change in England 1600-1642 (Cambridge, 1959).

Weitzman, M., "Contestable Markets: An Uprising in the Theory of Industry Structure: Comment," American Economic Review (June 1983), 486-487.

Wessel, J., "Baltimore's Dairy Industry and the Fight for Pure Milk, 1900-1920" (forthcoming in Business and Economic History ed. J. Atack, Urbana 1984).

Wilson, c., "The Nature of Equilibrium in Markets with Adverse Selection," The Bell Journal of Economics (1980), 108-130.

APPENDIX

The Appendix extends the model to the case where producers decide both the optimal quality and quantity. The firm now maximizes

$$p(\theta, \nu, q)\cdot q - C(\theta, q)$$

where a term involving quantity has now been included in both the demand and the cost function. The first order conditions are

$$p_1 - C_1 = 0.$$

$$p_1 q + p - C_2 = 0.$$

and the second-order conditions involves well-known restrictions on the signs of bordered determinants.

In order to obtain comparative static results we look at the total differentials of the first order conditions.

$$\begin{matrix} p_{11}q - C_{11} & p_{13}q + p_1 - C_{12} \\ p_{31}q + p_1 - C_{21} & p_{33}q + 2p_3 - C_{22} \end{matrix} \begin{matrix} \frac{\partial \theta}{\partial \nu} \\ \frac{\partial q}{\partial \nu} \end{matrix} = \begin{matrix} -p_{12}q \\ -p_{32}q - p_2 \end{matrix}$$

$$\frac{\partial \theta}{\partial \nu} = \frac{-p_{12}q(p_{33}q + 2p_3 - C_{22}) + (p_{23}q + p_2)(p_{13}q + p_1 - C_{12})}{|J|}$$

$$\frac{\partial q}{\partial \nu} = \frac{-(p_{23}q + p_2)(p_{11}q - C_{11} + p_{12}q(p_{21}q + p_1 - C_{21})}{|J|}$$

where $|J|$ is the determinant of the matrix on the left-hand side, which we know to be positive from the second-order conditions. The signs of

$\frac{\partial\theta}{\partial\nu}$ and $\frac{\partial q}{\partial\nu}$ obviously cannot be determined without making specific assumptions on the form of $p(\theta, \nu, q)$. If we continue with the extensions of the forms used earlier

A': $\quad p = \alpha + \beta\frac{a}{\nu} + \eta\theta + \delta q$

B': $\quad p = \alpha' + \beta'(\theta - \nu)^x + \eta'\theta + \delta q$, where $x = 1, 2$ or 3

Then some simple calculation indicate that, for example,

for A', $\frac{\partial\theta}{\partial\nu} < 0$ if $C_{12} \leq 0$; indeterminate otherwise

$\frac{\partial q}{\partial\nu} < 0$ if $C_{12} \leq 0$; indeterminate otherwise

for B', $x=1$ $\frac{\partial\theta}{\partial\nu} < 0$ if $C_{12} \leq 0$; indeterminate otherwise

$\frac{\partial q}{\partial\nu} < 0$ if $C_{12} \leq 0$; indeterminate otherwise

for B', $x=3$ $\frac{\partial\theta}{\partial\nu} \lessgtr 0$ if $\theta \lessgtr \nu$ provided $C_{12} \leq 0$.

$\frac{\partial q}{\partial\nu}$ is generally indeterminate.

The disturbing feature of the analysis just performed is that there are many cases when $\frac{\partial\theta}{\partial\nu} < 0$ seems a possibility, i.e., cases where individual producers who had substandard products to start with try to further worsen quality on hearing of a general improvement in quality. The condition to be fulfilled is that $C_{12} \leq 0$. Fortunately, if we consider the simplest sorts of food adulteration the "technology" will normally imply that $C_{12} > 0$, i.e., the marginal cost of production increases at higher qualities. This is not very much comfort, however,

because the sign of $\frac{\partial \bar{s}}{\partial v}$ now becomes merely indeterminate instead of being definitely perverse. It will be noted that the existence of many firms, some of whom deliver quality services and the others substandard ones is even found in developed economies; a U.S. Government survey in the Spring of 1979 claimed that one-half of all gas-stations were not competent at repairing cars!