II. THE MODEL WITH AUTOMOBILES AS AN EXAMPLE

A. *The Automobiles Market*

The example of used cars captures the essence of the problem. From time to time one hears either mention of or surprise at the large price difference between new cars and those which have just left the showroom. The usual lunch table justification for this phenomenon is the pure joy of owning a 'new' car. We offer a different explanation. Suppose (for the sake of clarity rather than reality) that there are just four kinds of cars. There are new cars and used cars. There are good cars and bad cars (which in America are known as 'lemons'). A new car may be a good car or a lemon, and of course the same is true of used cars.

The individuals in this market buy a new automobile without knowing whether the car they buy will be good or a lemon. But they do know that with probability q it is a good car and with probability $(1-q)$ it is a lemon; by assumption, q is the proportion of good cars produced and $(1-q)$ is the proportion of lemons.

After owning a specific car, however, for a length of time, the car owner can form a good idea of the quality of this machine; i.e., the owner assigns a new probability to the event that his car is a lemon. This estimate is more accurate than the original estimate. An asymmetry in available information has developed: for the sellers now have more knowledge about the quality of a car than the buyers. But good cars and bad cars must still sell at the same price—since it is impossible for a buyer to tell the difference between a good car and a bad car. It is apparent that a used car cannot have the same valuation as a new car—if it did have the same valuation, it would clearly be advantageous to trade a lemon at the price of new car, and buy another new car, at a higher probability q of being good and a lower probability of being bad. Thus the owner of a good machine must be locked in. Not only is it true that he cannot receive the true value of his car, but he cannot even obtain the expected value of a new car.

Gresham's law has made a modified reappearance. For most cars traded will be the 'lemons,' and good cars may not be traded at all. The 'bad' cars tend to drive out the good (in much the same way that bad money drives out the good). But the analogy with Gresham's law is not quite complete: bad cars drive out the good because they sell at the same price as good cars; similarly, bad money drives out good because the exchange rate is even. But the bad cars sell at the same price as good cars since it is impossible for a buyer to tell the difference between a good and a bad car; only the seller knows. In Gresham's law, however, presumably both buyer and seller can tell the difference between good and bad money. So the analogy is instructive, but not complete.

B. *Asymmetrical Information*

It has been seen that the good cars may be driven out of the market by the lemons. But in a more continuous case with different grades of goods, even worse pathologies can exist. For it is quite possible to have the bad driving out the not-so-bad driving out the medium driving out the not-so-good driving out the good in such a sequence of events that no market exists at all.

One can assume that the demand for used automobiles depends most strongly upon two variables—the price of the automobile p and the average quality of used cars traded, μ, or $Q^d = D(p, \mu)$. Both the supply of used cars and also the average quality μ will depend upon the price, or $\mu = \mu(p)$ and $S = S(p)$. And in equilibrium the supply must equal the demand for the given average quality, or $S(p) = D(p, \mu(p))$. As the price falls, normally the quality will also fall. And it is quite possible that no goods will be traded at any price level.

Such an example can be derived from utility theory. Assume that there are just two groups of traders: groups one and two. Give group one a utility function

$$U_1 = M + \sum_{i=1}^{n} x_i$$

where M is the consumption of goods other than automobiles, x_i is the quality of the ith automobile, and n is the number of automobiles.

Similarly, let

$$U_2 = M + \sum_{i=1}^{n} 3/2 x_i$$

where M, x_i, and n are defined as before.

Three comments should be made about these utility functions: (1) without linear utility (say with logarithmic utility) one gets needlessly mired in algebraic complication. (2) The use of linear utility allows a focus on the effects of asymmetry of information; with a concave utility function we would have to deal jointly with the usual risk-variance effects of uncertainty and the special effects we wish to discuss here. (3) U_1 and U_2 have the odd characteristic that the addition of a second car, or indeed a kth car, adds the same amount of utility as the first. Again realism is sacrificed to avoid a diversion from the proper focus.

To continue, it is assumed (1) that both type one traders and type two traders are von Neumann-Morgenstern maximizers of expected utility; (2) that group one has N cars with uniformly distributed quality x, $0 \leqq x \leqq 2$, and group two has no cars; (3) that the price of 'other goods' M is unity.

Denote the income (including that derived from the sale of automobiles) of all type one traders as Y_1 and the income of all type two traders as Y_2. The demand for used cars will be the sum of the demands by both groups. When one ignores indivisibilities, the demand for automobiles by type one traders will be

$$\begin{aligned} D_1 &= Y_1/p \qquad && \mu/p > 1 \\ D_1 &= 0 && \mu/p < 1. \end{aligned}$$

And the supply of cars offered by type one traders is

$$S_2 = pN/2 \qquad p \leqq 2 \tag{1}$$

with average quality

$$\mu = p/2. \tag{2}$$

(To derive (1) and (2), the uniform distribution of automobile quality is used.)

Similarly the demand of type two traders is

$$\begin{aligned} D_2 &= Y_2/p & 3\mu/2 &> p \\ D_2 &= 0 & 3\mu/2 &< p \end{aligned}$$

and

$$S_2 = 0.$$

Thus total demand $D(p, \mu)$ is

$$\begin{aligned} D(p, \mu) &= (Y_2 + Y_1)/p & &\text{if } p < \mu \\ D(p, \mu) &= Y_2/p & &\text{if } \mu < p < 3\mu/2 \\ D(p, \mu) &= 0 & &\text{if } p > 3\mu/2. \end{aligned}$$

However, with price p, average quality is $p/2$ and therefore at no price will any trade take place at all: in spite of the fact that *at any given price* between 0 and 3 there are traders of type one who are willing to sell their automobiles at a price which traders of type two are willing to pay.

C. *Symmetric Information*

The foregoing is contrasted with the case of symmetric information. Suppose that the quality of all cars is uniformly distributed, $0 \leqq x \leqq 2$. Then the demand curves and supply curves can be written as follows:

Supply

$$\begin{aligned} S(p) &= N & p &> 1 \\ S(p) &= 0 & p &< 1. \end{aligned}$$

And the demand curves are

$$\begin{aligned} D(p) &= (Y_2 + Y_1)/p & p &< 1 \\ D(p) &= (Y_2/p) & 1 < p &< 3/2 \\ D(p) &= 0 & p &> 3/2. \end{aligned}$$

In equilibrium

$$p = 1 \qquad \text{if } Y_2 < N \tag{3}$$

$$p = Y_2/N \qquad \text{if } 2Y_2/3 < N < Y_2 \tag{4}$$

$$p = 3/2 \qquad \text{if } N < 2Y_2/3. \tag{5}$$

If $N < Y_2$ there is a gain in utility over the case of asymmetrical information of $N/2$. (If $N > Y_2$, in which case the income of type two traders is insufficient to buy all N automobiles, there is a gain in utility of $Y_2/2$ units.)

Finally, it should be mentioned that in this example, if traders of groups one and two have the same probabilistic estimates about the quality of individual automobiles—though these estimates may vary from automobile to automobile—(3), (4), and (5) will still describe equilibrium with one slight change: p will then represent the expected price of one quality unit.

III. EXAMPLES AND APPLICATIONS

A. *Insurance*

It is a well-known fact that people over 65 have great difficulty in buying medical insurance. The natural question arises: why doesn't the price rise to match the risk?

Our answer is that as the price level rises the people who insure themselves will be those who are increasingly certain that they will need the insurance; for error in medical check-ups, doctors' sympathy with older patients, and so on make it much easier for the applicant to assess the risks involved than the insurance company. The result is that the average medical condition of insurance applicants deteriorates as the price level rises—with the result that no insurance sales may take place at any price.[1] This is strictly analogous to our automobiles case, where the average quality of used cars supplied fell with a corresponding fall in the price level. This agrees with the explanation in insurance textbooks:

> Generally speaking policies are not available at ages materially greater than sixty-five.... The term premiums are too high for any but the most pessimistic (which is to say the least healthy) insureds to find attractive. Thus there is a severe problem of adverse selection at these ages.[2]

The statistics do not contradict this conclusion. While demands for health insurance rise with age, a 1956 national sample survey of 2,809 families with 8,898 persons shows that hospital insurance coverage drops from 63 per cent of those aged 45 to 54,

[1] Arrow's fine article, 'Uncertainty and Medical Care' (*American Economic Review*, Vol. 53, 1963), does not make this point explicitly. He emphasizes 'moral hazard' rather than 'adverse selection.' In its strict sense, the presence of 'moral hazard' is equally disadvantageous for both governmental and private programs; in its broader sense, which includes 'adverse selection,' 'moral hazard' gives a decided advantage to government insurance programs.

[2] O. D. Dickerson, *Health Insurance* (Homewood, Ill.: Irwin, 1959), p. 333.