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Gilroy, Bernard Michael and Broll, Udo

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B. Michael Gilroy; Udo Broll*

1. Introduction

The importance of informational aspects of market processes has received considerable attention [see e.g. Osayimwese (1978) in this Journal]. This paper considers the problem of adverse selection and the possible outcomes under different risk behaviour assumptions. Akerlof [1970] first examined the effects of product quality uncertainty as demonstrated in the used car market. Adverse selection arises in situations in which buyers are only able to observe the average quality of the products they wish to purchase, the sellers on the other hand are assumed to know the quality of their product. This asymmetry in information between the market agents may then lead to a situation whereby sellers of high quality merchandise are not sufficiently rewarded and they tend to leave the market, so that only poor quality goods will be offered for sale [compare e.g. Varian (1984). Chapter 8, Hey (1979), Part III]. The analysis presented here deals explicitly with the situation given in the used car market; however, the principle of adverse selection may be observed in many market situations, an important being the credit market [see e.g. Milde (1980), Broll and Gilroy (1986)].

The general situation in the used car market can be described as follows. In the original situation, there exist only four types of automobiles : there are new cars and old cars both of which may be of good quality or poor quality. Poor quality cars may be termed as "lemons". Buying a new car is a lottery; both the seller and the buyer are unaware of the actual car quality.

After a certain period of ownership the purchaser of a new car has had a chance to find out about the quality of his car. According

*Teaching Assistants, Dept. of Economics, University of Konstanz, West Germany.

to this newly gathered information he revises his probability estimate concerning the quality of his automobile, this new estimate being more accurate than the first. Deciding then to sell his car, the owner possesses more information about the quality of the car than a potential buyer. A situation has thus arisen in which asymmetry in available information is given. 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 lemon. There exists an incentive for sellers to offer only the lower quality cars for sale, which tends to lower the average quality of cars in the used car market and eventually the size of the market itself.

The paper is structured as follows : section II presents briefly some general implications of risk aversive behaviour. Two common measures of risk are introduced and the possibility of using a mean-variance analysis in considering types of risk behaviour is discussed. Section III then analyses Akerlof's model under the assumption of risk aversive behaviour. It is shown that the introduction of risk aversive behaviour strengthens the adverse selection process, having an even greater negative effect upon the market structure. Finally, section IV draws some general conclusions about the process of adverse selection and briefly discusses possible counteracting institutions.

II. Risk Behaviour

Working within the expected utility framework, whereby the economic agents are faced with an uncertainty situation, it will be assumed that the individuals act so as to maximize their expected utility of the random outcome.

An agent may then be said to be risk averse if for all possible wealth (W=wealth) and risk (X=product quality, for example) combinations, the agent prefers $W+E[X]$ to $W+X$, where $E[.]$ represents the expectations operator. Thus risk aversion may be defined as

$$(1) \qquad EU(W+X) \leqslant U(W+EX),$$

for all W and X.

Risk aversion implies diminishing marginal returns to utility. A further implication of risk aversion is that the utility function must be concave. Concavity of the expected utility function is thereby equivalent to risk aversion.

Assuming that $U[c]=EU(W+X]$, with c denoting the certainty equivalent, one may derive the inverse function to obtain, $c=U^{-1}[EU[W+X]]$. Thus, the following theorem may be formulated : an agent is risk averse if and only if $c \leqslant W+E[X]$.

The next step is to find an appropriate measure of risk aversion. One would expect intuitively that the more concave the expected utility function is, the more risk averse the consumer. However, this measure does not remain invariant to changes in the expected utility function. Taking the second derivative and normalizing it by dividing it by the first derivative one obtains the following concepts :

—absolute risk aversion : $R_A=-U''/U'$

—relative risk aversion : $R_R=-Y \cdot U''/U'$, with Y denoting income.

The degree of relative risk aversion may be considered as the elasticity of marginal utility of wealth. The quicker marginal utility decreases, the more risk aversion that will be displayed by the agent. Constant absolute risk aversion simply means that an individual will rank uncertain situations the same way independent of his income level. On the other hand, if an individual exhibits constant relative risk aversion, he will be less averse to risk the higher his income level is. The following tow hypotheses are commonly found in the literature:

—Increasing Relative Risk Aversion.
The relative risk aversoion R_R is an increasing function of income.

—Decreasing Absolute Risk Aversion.
The absolute risk aversion R_A is a decreasing function of income.[1]

The utility function that is often applied in risk aversion analysis of the following quadratic form with the stochastic variable $U[X]=a+bX+cX^2$. This function may be reformulated using the mean μ and variance σ^2 of the variable X as $E[U[X]]=a+b\mu+c[\mu^2+\sigma^2]$. This function may be further rewritten as a risk utility function dependent upon the mean μ and the variance σ^2 :

$$(2) \quad u=g(\mu, \sigma^2)$$

[1] See the excellent up-to-date list of references found in Lippman and McCall (1981).

A marginal risk substitution rate can be derived by taking the total differential of the above risk utility function.

Risk behaviour may then be characterized in three possible forms :

for $c<0,\ \frac{d\mu}{d\sigma^2}>0,$ agent is a risk averter,

for $c=0,\ \frac{d\mu}{d\sigma^2}=0,$ agent is risk neutral,

for $c>0,\ \frac{d\mu}{d\sigma^2}<0,$ agent is a risk lover

The situation $c=0$ is simply the case of linear utility function as originally examined in Akerlof's used car market model [Akerlof (1970)].

Important for the indifference mapping of an individual who exhibits risk neutral behaviour is only the value μ and not σ^2. In the case of a risk averter, however, there exists a trade-off relationship between μ and σ^2 therefore,

$$u=g(\mu, \sigma^2)$$

$$\text{with } \frac{\partial g}{\partial \mu}>0, \frac{\partial g}{\partial \sigma^2}<0.$$

Each new higher risk level must be compensated for by a higher expected value. The case of a risk lover is economically uninteresting and will be neglected hereafter.

A marginal risk substitution rate can be derived by taking the total differential of the above risk utility function :

$$\frac{\partial u}{\partial \mu}\cdot d\mu + \frac{\partial u}{\partial \sigma^2}\cdot d\sigma^2 \overset{!}{=} 0,$$

$$\frac{d\mu}{d\sigma^2} = -\frac{\partial u/\partial \sigma^2}{\partial u/\partial \mu}.$$

Risk behaviour may be characterized in three possible forms ;

for $c<0,\ \frac{d\mu}{d\sigma^2}>0,$ agent is a risk averter,

for $c=0,\ \frac{d\mu}{d\sigma^2}=0,$ agent is risk neutral,

for $c>0,\ \frac{d\mu}{d\sigma^2}<0.$ agent is a risk lover, The situation $c = 0$ is simply the case of a linear utility function as will be examined in the used car market under the assumption of risk neutrality ($c=0$). The case $c > 0$, a risk lover, is of little economic significance

Important for the indifference mapping of an individual who exhibits risk netural behaviour is only the value μ and not σ^2, so that we may write the risk utility function as,

$$u = g(\underset{(+)}{\mu}, \underset{(0)}{\sigma^2}) \qquad \text{and} \qquad N\sigma^2 = 0 .$$

In the case of a risk averter there exists, however, a trade-off relationship between μ and σ^2 therefore.

$$u = g(\underset{(+)}{\mu}, \underset{(-)}{\sigma^2}) .$$

Each new higher risk level must be compensated for by a higher expected value.

A risk lover, on the other hand, is willing to sacrifice more of his wealth in order to involve himself in a higher risk situation.

$$u=g(\underset{(+)}{\mu}, \underset{(+)}{\sigma^2} .$$

III. The Market for Lemons

In this section the effects *quality uncertainty* and risk aversive behaviour upon the used car market will be examined. It will be shown that the presence of risk aversive behaviour strengthens the process of adverse selection that exists in markets with information asymmetry, and may lead to a total breakdown of the competitive market structure.

The basic model of the used car market may be presented as follows. The potential *seller* of a car, designated by the subscript j, has a utility function of the form, $U_j=M + \alpha_j X$ (whereby U_j=utility fuction of individual j, M = utility derived form other consumer goods under the simplification that their price is normalized to one, X quality of the used car, and α_j subjective marginal rate of substitution). The potential seller is assumed to exhibit risk neutral behaviour, as suggested by his linear utility function.

If the owner does sell his car, the utility function must be rewritten as $U_j=M + \alpha_j X+p-\alpha_j X$, or $U_j=M+p$, with p designating the price of the automobile. A car will be sold only in situations in which the expected utility after sale is larger than the utility before the sale, that is $M+p > M + a_jX$.

Rewriting the potential seller's situation using the expectations operator E, the nonsale of the car is derived as $E[U_j]=M+a_jE[X]$. If the car is sold we obtain, $E[U_j]=M+p$. It follows that $M+p>M+ a_jE[X]$. The decision rule for a car sale to occur is $p > a_jE[X]$, which is equivalent to $p > a_jE(X)$. The owner will sell his car only when the sales price is greater than his subjective quality estimation of the car weighted with his subjective marginal rate of substitution a_j. In the situation wherby $p < a_jE(X)$, no car sale will occur. The critical limit whereby the potential seller is indifferent as to selling or not is then $p=a_j \cdot E(X)$, whereby $E[X] \equiv \mu$.

The potential *buyer* of a used car, however, not knowing the automobile's quality with certainty, will be assumed to exhibit risk aversive behaviour. Using the subscript i to designate a potential buyer, his utility function may be characterized as $U_i=M+ a_iX-\beta_i \cdot X^2$.

If no purchase occurs, the buyer's utility function will be simply $U_i=M$. On the other hand, if the buyer does purchase a used car, his utility function becomes $U_i=M-p+a_iX - \beta_iX^2$.
The buyer will therefore only purchase a used car given the situation, $M-p + a_iX-\beta_iX^2 > M$. In other words, a used car will be purchased given that the expected utility of an automobile is large enough to compensate the sacrifices in consumption of other goods. The purchase dicision rule for a potential buyer is therefore $a_iX-\beta_iX^2 > p$. Given the opposite situation $a_iX-\beta_iX^2 < p$, no purchase will take place. The potential buyer is indifferent as to a used car purchase given the critical limit. $a_iX-\beta_iX^2=p$.

Reformulating the potential buyer's decision rules using the expectations operator E along with the existing relationships for μ and σ^2, we may combine the general decision rules for the basic used car market model under risk aversion in the following table.

Table 1

Potential Buyer	Decision Rule	Potential Seller	Decision Rule
Purchase	$a_i\mu(p) - \beta_i(\sigma^2(p) + \mu^2(p)) > p$	Sell	$p > a_j \cdot \mu$
Indifferent	$a_i\mu(p) - \beta_i(\sigma^2(p) + \mu^2(p)) = p$	Indifferent	$p = a_j \cdot \mu$
No Purchase	$a_i\mu(p) - \beta_i(\sigma^2(p) + \mu^2(p)) < p$	No Sale	$p < a_j \cdot \mu$

As is well known, the variance of a stochastic variable is defined as :

$$Var\,[X] = E\,[(X - E[X])^2)]$$

or rearranging,

$$E\,[X^2] = Var\,[X] + (E\,[X])^2$$

Re-examining the potential buyer's utility function, the expected utility after a car purchase is derived as $E\,[U_i] = M + a_i E\,[X] - \beta_i E\,[X^2] - p$. Substituting the above derived value for $E\,[X^2]$ in this eqation we obtain. $E[U_i] = M + a_i E[X] - \beta_i (E[X])^2 - \beta_i \cdot Var\,[X] - p$. The decision rule to purchase a used car may be expressed then as, $a_i E[X] - \beta_i (E\,[X])^2 - \beta_i Var\,[X] > p$ Equivalently, we may write $a_i E\,[X] - p > \beta_i (E[X])^2 + \beta_i Var\,[X]$. The term on the left-hand side of the last inequality is the same as will be found for the linear utility function where $\beta_i = 0$. The term on the right-hand side of the equation. depends significantly upon the value assigned to β_i.

Expressing the general decision rules just discussed in this form we obtain :

Table 2

Potential Buyer	Decision Rule	Potential Seller	Decision Rule
Purchase	$a_i E[X] - \beta_i (E[X])^2 - \beta_i Var\,[X] > p$	Sell	$p > a_j \cdot \mu$
Indifferent	$a_i E[X] - \beta_i (E[X])^2 - \beta_i Var[X] = p$	Indifferent	$p = a_j \cdot \mu$
No Purchase	$a_i E[X] - \beta_i (E[X])^2 - \beta_i Var\,[X] < p$	No Sale	$p < a_j \cdot \mu$

In order to illustrate the potential buyer's reactions under these decision rules, we will consider three possible density functions. The first density function (Case 1) has the following form :

$$(3) \qquad f(X) = \begin{cases} 1 & \text{for } 0 \leqslant X \leqslant 1, \\ 0 & \text{otherwise}. \end{cases}$$

The 'conditional expected value' of X can given as,

$$E\,[X] = \frac{\int_0^p X \cdot f(X) dX}{\int_0^p f(X) dX} = \frac{1/2p^2}{p} = 1/2 \cdot p$$

The conditional value for $E[X^2]$ is derived as,

$$E[X^2] = \frac{{}_0\int^p X^2 \cdot f(X)\,dX}{{}_0\int^p f(X)\,dX} = \frac{1/3p^3}{p} = 1/3\,p^2 \quad .$$

Through simple substitution therefore we obtain.

$$Var[X] = E[X^2] - (E\,[X])^2 = 1/3p^2 - (1/2p)^2 = 1/3p^2 - 1/4p^2 = 1/12p^2$$

Substituting these values into the *no purchase rule* of Table 2 gives us,

$$\alpha_i E[X] - p < \beta_i (E[X])^2 + \beta_i Var[X] \quad .$$

$$\alpha_i 1/2p \;-\; p < \beta_i (1/4p^2 + 1/12p^2) \quad ,$$

$$\alpha_i p(1/2 - 1/\alpha_i) < \beta_i (1/3p^2) \quad ,$$

or

$$3 \cdot \frac{\alpha_i}{\beta_i} (1/2 - 1/\alpha_i) < p \quad ,$$

whereby the price p can have at most a zero minimum.

Given the values $\alpha_i = 3/2$ and $\beta_i = 1/2$, the above equation leads to the no purchase decision rule, $-3/2 < p$. Since a seller is prepared only at a positive price to offer a car for sale, whereas potential buyers are not willing to pay a positive price under these subjective quality estimates of the cars, this sort of market constellation will be characterized by an excess supply of used cars for all prices at which $p > 0$. Excess supply normally forces the price to decrease; however, since the price level may not be negative according to assumption, there exists no equilibrium transaction level. Under these market conditions no used car sales will be transacted.

The second density function (Case 2) is characterized as :

$$(4) \qquad f(X) = \begin{cases} 2\,X \text{ for } 0 < X < 1 & , \\ 0 \quad \text{otherwise} & . \end{cases}$$

For the 'conditional expected value' of X we obtain,

$$E[X] = \frac{{}_0\int PX \cdot f(X)dX}{{}_0\int P f(X) PX} = \frac{1/3P^3}{1/2P^2} = 2/3p \quad .$$

The conditional value for $E[X^2]$ is derived as,

$$E[X^2] = \frac{{}_0\int PX^2 \cdot f(X)\,dX}{{}_0\int P f(X)\,dX} = \frac{1/4p^4}{1/2p^2} = \tfrac{1}{2}p^2 \quad ,$$

Substituting these values into the variance definition it follows that,

$$Var\,[X]=E[X^2]-(E[X])^2=1/2_p{}^2-(2/3_p)^2=1/18_p{}^2$$

Seting the above values into the no purchase rule of Table 2 again, we have

$$\alpha_i\ E[X]-p<\beta_i((E[X])^2+Var[X])$$

or

$$\frac{18}{9}\cdot\frac{\alpha_i}{\beta_i}\left(\tfrac{2}{3}-\frac{1}{\alpha_i}\right)<p \quad .$$

Having the values $\alpha_i=3/2$ and $\beta_i=1/2$, the above equation leads to the no purchase decision rule $0<p$. Once again the market constellation is such that the subjective quality estimates of used cars is not adequate enough in order for the potential buyers to be willing to pay a positive price, with the consequence that for all prices at which $p>0$ an excess supply of used cars exists. Due to this excess supply, the price of a used car demanded by the seller must decrease until the critical limit $p=0$ is obtained, the equilibrium price is zero. Given a price $p=0$, both the buyer and seller are indifferent towards used car transactions. However, assuming that sellers maximize their utility under "self-interest," it is more or less a matter of definition as to an equilibrium concept with a zero price. Market exchanges of used cars will not take place at a zero price level. The market for used cars under these conditions will be non-existent as long as the potential buyers do not change their subjective quality estimates of the used cars.

Finally, the third density function is of the following form :

$$(5)\qquad f(X)=\begin{cases}3X^2 & \text{for } 0\leqslant X\leqslant 1\quad ,\\ 0 & \text{otherwise}\quad .\end{cases}$$

Deriving the conditional expected value of X we have,

$$E\,[X]\ \frac{{}_0\!\int^P X\cdot f\,(X)\,dX}{{}_0\!\int^P f\,(X)\,dX}=\frac{1/4P^4}{1/3P^3}=3/4p \quad .$$

The conditional expected value $E\,[X^2]$ is,

$$E[X^2]=\frac{{}_0\!\int^P X^2\cdot f\,(X)\,dX}{{}_0\!\int^P f\,(X)\,dX}=\frac{1/5P^5}{1/3P^3}=3/5P^2 \quad .$$

Applying the variance definition using the above values it follows that,

$$Var\,[X]=E[X^2]-(E_i[X])^2=3/5\,P^2-(3/4\,P)^2=8/80\,P^2.$$

Substituting the necessary values into the no purchase decision rule of Table 1 we obtain,

$$\alpha_i E[X] - p < \beta_i((E[X])^2 + Var\,[X]) \quad ,$$

or

$$5/3 \cdot \frac{\alpha_i}{\beta_i} \left(\frac{3}{4} - \frac{1}{\sigma_i}\right) < p \quad .$$

Given the values $\alpha_i = 3/2$ and $\beta_i = 1/2$, in this specific situation the critical limit is therefore given by the price $p = 5/12$. At the price 5/12 and only at this price market transactions will take place, with the market demand and supply being in equilibrium. It can be shown that under the assumption of *risk neutrality* and identical assumptions used above, the critical limit using the Case 3 density function will be 9/8. This means that in situations with risk aversion the buyers will be more careful in considering what to purchase than in situations under risk neutrality, causing the price to fall from 9/8 to 5/12. The exchange rate of used cars will be slower under risk aversion and the demand for used cars will be smaller, thus decreasing the price which may be demanded by the seller for his automobile. Risk aversive behaviour thereby intensifies the process of adverse selection.

The results of the analysis for the three different density functions under risk aversive behaviour may be presented briefly in the following table :

Table 3

	Risk neutral behaviour	Risk aversive behaviour
Case 1	for $p \geqslant 0$ excess supply	for $p \geqslant 0$ excess supply
Case 2	equilibrium price lies within the range $0 \leqslant p \leqslant 1$	for $p > 0$ excess supply for $p = 0$ equilibrium
Case 3	The equilibrium price is exactly 9/8.	The equilibrium price is exactly 5/12.

Due to the asymmetry in information (i.e. the buyer's ignorance and the seller's assumed knowledge), *average* used car equlity is *dependent* upon the price. A decrease in the market price leads to a reduction in the quantity offered for sale along with a decrease in the average quality. If the potential buyer is able to perceive this decrease in average quality, the quantity demanded may fall sufficiently so that an equilibrium may not exist. From Table 3 it is apparent that risk aversive behaviour further strengthens the market disturbing tendencies due to this information asymmetry. The larger the financial investment in a desired product, the more important becomes the acquisition of product quality information.

IV. Conclusion

The analysis has shown that given situations in which product quality uncertainty exists, information asymmetry among the exchange partners arises which causes adverse selection to occur. It has heen demonstrated that under risk aversive (and risk neutral) behaviour the process of adverse selection may lead to market non-existence. This market break-down situation is inefficient for all concerned, since the possibility of making information more equally available to both exchange partners would enable a better risk distribution profile. This would lead to more used car sales, increasing the agent's utility levels and welfare of all parties involved.

Akerlof's analysis of asymmetrical information demonstrates the most extreme situation, namely a total market break-down. However, as Akerlof himself realizes, this does not accord with reality. The used car market does exist.

Many counteracting institutions have arisen to deal with the effects of quality uncertainly. In most markets, product guarantees transfer questions of risk from the buyers to the sellers, thereby eliminating largely the problem of consumer information asymmetry.

Brand-names are also present in most markets upon which consumers base their quality decisions. Brand-names give consumers a means of retaliation; if disappointed in product quality they may decide simply not to purchase a specific brand-name in the future. Chains—such as resaurant or department store chains - offer a further possibility of reducing consumer quality risk. Licensing practices in most professional jobs help to guarantee a minimum threshold for the service quality offered.

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