Adverse Selection in the Wholesale Used Car Market

David Genesove

Massachusetts Institute of Technology

This paper presents an empirical investigation of adverse selection in the wholesale used car market. New car dealers (who sell both new and used cars) differ from used car dealers (who sell only used cars) in the propensity to sell trade-ins on the wholesale market. Models of adverse selection suggest that the dealer type that sells a higher proportion of its trade-ins on the wholesale market will sell, on average, cars of higher quality and receive in return a higher price. A survey of dealers' wholesale behavior and prices collected at a wholesale auction are used to test this prediction. I find weak evidence for adverse selection.

I. Introduction

You are offered, by each of two individuals, an apple. The two apples appear identical. The sellers, however, differ: seller A hates apples and has inherited an orchard filled with apple trees; seller B loves apples and is endowed with an orchard scarce in apple trees. From whom will you buy?

In the canonical, perfect information market for apples you would be indifferent. The two objects are the same commodity; what do the

This is a revision of a chapter of my dissertation, "Coconuts, Lemons and Pies: Search, Adverse Selection and Bargaining in the Wholesale Used Car Market." Funding from Princeton University's John M. Olin Program for the Study of Economic Organization and Public Policy, the Sloan Foundation, and the Social Sciences and Humanities Research Council of Canada is gratefully acknowledged. Thanks to Jim Lacko and the Federal Trade Commission for use of the 1979 survey. I owe special thanks to the officers of the auction house, whose cooperation was essential to this work.

[*Journal of Political Economy*, 1993, vol. 101, no. 4]
 0022-3808/93/0104-0009$01.50

characteristics of the sellers matter? But the market for "lemons" is different. Say, then, that there is some attribute of apples that is not discernible to the buyer at the time of purchase, but of which the seller is fully informed. Some apples are good, some bad; and though the seller can tell them apart, the buyer cannot. From whom would you buy now?

It is in the interest of both sellers to sell all their bad apples on the market, to obtain in return apples of a quality whose average is that of all apples traded, or the monetary equivalent. Seller A, having more apples than he wants, will sell some of his good apples as well. Seller B has no reason to sell good apples, not having enough of them as it is. He sells only to take advantage of the buyer's ignorance. We should expect, then, that at any given price A will offer apples that, on average, are of higher quality than those of B and will offer a higher fraction of his crop as well. An equilibrium in which the final price reflects the average quality of the good traded will have apples offered by A selling at a higher price than those of B.

These observations suggest a test for adverse selection. Where sellers differ according to some recognizable type, the type that has a greater propensity to sell will obtain a higher price for observably identical goods, if adverse selection is prevalent in the market. I apply this test to the wholesale used car market by comparing the difference in the fraction of trade-ins sold wholesale to the difference in price received at a wholesale auction, by model year, for two types of sellers: new car dealers, who maintain, in addition to their used car business, a new car dealership franchise; and used car dealers, who retail used cars only. Prices were obtained in visits to an auction during the summer of 1989; estimates of the propensity to sell wholesale come from a survey of dealers in a 150-mile vicinity of the auction in the fall of that same year.

Previous work on adverse selection in used vehicles includes papers by Bond (1982, 1984), who compared the frequency of maintenance of trucks purchased new and trucks purchased used; and Lacko (1986), who considered the difference in (owner-reported) quality of cars purchased from friends or relatives and cars purchased through newspaper ads. Both found evidence of adverse selection among older vehicles only. Work on other "lemons" markets includes Greenwald and Glasspiegel's (1983) analysis of the New Orleans slave market and Gibbons and Katz's (1991) comparison of the subsequent wages of workers displaced by plant closings and other causes.

The remainder of the paper is organized as follows. Section II describes the wholesale used automobile market. Section III examines whether the theoretical conditions for a lemons market exist in this market. Section IV compares new car dealers to used car dealers.

Section V sketches a model of adverse selection in this market. Section VI presents the dealer survey, Section VII the auction data, and Section VIII the estimates of the price differentials, along with the other coefficients of a hedonic equation. Section IX is a brief conclusion.

II. The Wholesale Used Car Market

Wholesale auto auctions,[1] which on the buyers' side are limited to dealers and on the sellers' side to dealers and owners of large fleets, serve mainly as a means by which dealers can adjust the composition of their stock of used cars. Having a well-balanced inventory of cars is viewed as good business practice in the used car industry. However, dealers obtain much of their stock as trade-ins from their customers. The auction provides a market in which a dealer can, in effect, trade one car for another and thereby transform the portfolio of cars received as trade-ins to one nearer to his retail needs, a process known as stock management. One big Edgeworth box, the auto auction is probably as close as one can get to the idealized Walrasian exchange economy, if information is symmetric in this market. But if it is not, then the opportunity to use the auction not only as a place of exchange but also as a dumping ground for "lemons" must necessarily arise.

Cars are traded in the following manner. Prior to the bidding, the car is parked outside, where potential bidders can examine its exterior. They are prohibited from opening the doors or raising the hood. Mileage and options are chalked on the car's windows. When the car's turn approaches, it is driven into the appropriate lane and then, before bidding is concluded on the previous car, driven up to the auction block. Now the hood is raised and dealers are permitted to enter the car. There is time to check the odometer, to ensure that the air conditioner works (but, in the summer months at least, not the heater), and to take a look at the running motor. But there is no opportunity to test the brakes or any number of other things that a consumer might check out in a drive around the block. (And I have heard engines fail in the middle of the bidding; perhaps this was no surprise to the bidders, but anyone who has brought a car with a worrisome noise into the shop to be fixed, only for the engine then

[1] There are about 300 wholesale auto auctions in the United States and Canada (personal correspondence from Bernard Hart [1989]), with combined sales in 1987 of over $20.4 billion or 5 million vehicles (cars and pickup trucks). By comparison, approximately 16 million used cars were sold retail in 1986 (Hertz Corp.). Until 1980, most auctions were independent. Since then, there has been an astonishing growth in the three major chains, each now including about 20 auctions, among them the 10 largest auctions (Thomas 1987).

to run smoothly, knows that one quick glance under the hood does not reveal all.)

On top of the auction block stands the auctioneer and, beside him, the seller, who under the rules of the auction must be present. The auctioneer announces any major defects in the car, of which the seller has informed him. Bidding is oral and ascending. When bidding will go no higher, the seller is asked to accept or reject the winning bid. About 60 percent of the time he accepts.[2] The car will have been driven away before the bidding is concluded. From the time it arrived at the auction block until the time it is driven away, a minute and a half will have passed.

III. Adverse Selection

The following conditions are necessary for a market to exhibit adverse selection in the sense of Akerlof (1970): (1) At the time of sale, one side of the market is better able to discern the quality of the good than the other. (2) Both buyer and seller value quality. (3) Price is not determined by the (more) informed party. (4) Extratrading institutions, such as warranties and reputations, do not fully eliminate uncertainty over quality.

In this market, the seller is clearly better informed than the buyer. The time allotted to bidders to examine the car is very short, whereas the seller has ample time to examine the car on his lot. Also, the seller may have serviced the car before receiving it in trade from the consumer and, thus, may be familiar with its history.

That both buyer and seller value quality is less obvious. Dealers' demand for quality is derivative: dealers care about quality only to the extent that consumers both care about quality and recognize it. Consider the extreme case in which consumers cannot discern quality at all. Then any given dealer will obtain the same price from a consumer for a good car as for a bad car. As this will be true for all dealers, all participants at the auction will value good and bad cars equally.

For dealers to care about quality, there must be either a long-term relationship between dealer and consumer or some chance that flaws overlooked at the auction will be subsequently noticed by a consumer on the lot. The latter is possible given the speed of transaction at the auction. The former is embodied in warranties and reputation. If consumers are more risk averse than dealers, dealers will offer con-

[2] The acceptance/rejection decision is interpreted in Genesove (1993) as seller search. Sometimes bargaining between the seller and the high bidder follows a rejected winning bid, but rarely does it end in trade.

sumers a more complete warranty than that offered by the seller at the auction (really, the recourse to arbitration over selected items within an hour of the bidding). Thus, even if the consumer were completely unable to observe quality at the time of purchase, the quality of the car would still determine the dealer's profit. In this case, the "quality" of a car to a dealer would be the expected savings on repair costs under the warranty. In fact, the survey by the Federal Trade Commission (FTC) described below indicates that one-third of purchases of used cars from dealers are accompanied by a warranty. A similar argument could be made where dealers form valuable reputations in the retail markets; there, "quality" is the expected value of repeat sales.

The third condition arises from theoretical work that argues that seller-announced prices might signal quality, even perfectly as in a separating equilibrium, and thus alleviate the adverse selection problem (Wilson 1980; Wolinsky 1983). Clearly, a reserve bid at an auction would serve a similar function: sellers who set a high reserve bid would signal their unwillingness to part with the good and thereby indicate the good's quality. But bidding is "without reserve" at this and most other auto auctions. The seller has the opportunity to reject the winning bid, but since this follows the bidding, the winning bid will be determined independently of the seller and the seller's private information.

Heal's (1976) early criticism of Akerlof's paper was that markets characterized by the first three conditions would give rise to reputations, and sellers would decline to take advantage of buyers' ignorance in order to protect their long-term interest. Many of the dealers are indeed regulars. But many, also, are not;[3] and for reputation to work, there must be regulars on both sides of the market. Also, the auction is large enough, and the attending dealers sufficiently diverse in their ethnicities, that both economic and social sanctions may prove difficult for buyers to apply against the offending seller.

The practice of "selling by if" provides stronger evidence of reputation. The standard requirement that the seller attend the bidding is occasionally set aside, should the seller be engaged elsewhere, notably in offering another car on a different lane. The seller is then permitted to "sell by if": bidding is held in his absence, and when he is free of his other duties, he is told the winning bid and, as usual, either accepts or declines. But in this case the buyer, too, can reject the

[3] Evidence is provided by reaction to my transcription of prices. This so worried the dealers during a single visit to a much smaller auction that the auction owner felt constrained to introduce me and explain my purpose at the end of bidding. In contrast, not until after several visits to the large auction discussed here did members start questioning me.

winning bid. Since the only difference to the buyer between this practice and the normal one is knowledge of the seller's identity, this strongly suggests that reputation plays some role in this market.

The auction house maintains an arbitrator on site, whose ruling is final. The arbitration system itself attests to the inability of dealers to perfectly evaluate the car at the time of sale. If it were to fully certify the quality of the car, there would, of course, be no remaining problem of asymmetric information in the wholesale market. But arbitration deals with the grossest deceptions only. Grounds for rejection are generally limited to undeclared prior use (as a taxi, police, or rental car) or undeclared gross defects, such as inoperative brakes. Defects in less essential components, such as the steering, springs and shocks, accessories, alternator, starter, distributor, carburetor, transmission, and the like, cannot be addressed by the arbitrator. Also, any complaints must be brought to the arbitrator within an hour of purchase. As the auction house also forbids test driving on its lot and as the buyer may have other commitments (such as selling a different car) in that hour, this may prove to be a true constraint. The auction house's coercive power is its ability to exclude dealers from future participation at the auction, and casual observation reveals that it uses that power.[4]

Although one might argue that those flaws not covered by arbitration must be unimportant, the substantial variation of coverage between auction houses suggests otherwise. Grieve (1983) concluded that of two Chicago wholesale auto auctions located 5 miles apart, prices at the auction with the more inclusive arbitration system were, on average, 3 percent higher. Since the grounds for arbitration at the less inclusive auction are similar to those of the auction reported here, Grieve's finding indicates that there are attributes of cars, unobservable to bidders but not covered by the arbitration system, that dealers yet care about.

No warranties are provided by either the auction house or the seller, although there have been indications in the press that auction houses may begin to offer them.

Akerlof's (1976) response to Heal conceded that such extracompetitive institutions as these would arise in the presence of asymmetric information, but noted that they would not "return the economy to competitive equilibrium, in which rewards are solely dependent on technical productivity" (p. 503). An alternative response is that the

[4] The clerk at each auction block has a list of some 30 or 40 dealers who have been excluded from the auction. As there are grounds for exclusion other than nonadherence to the arbitrator's ruling—such as credit default or bringing a retail customer to the auction—I cannot be sure of the frequency of exclusion for the first cause.

question of whether these institutions do suffice to rid the market of such behavior completely is primarily an empirical one (Bond 1982). Clearly, these institutions exist at wholesale auto auctions. Their mere presence suggests that quality is difficult to determine. What remains to be seen is whether they do, indeed, suffice to rid the market of adverse selection completely, so that the same average quality that would appear in a world of perfect information is traded in the market.

IV. New Car Dealers and Used Car Dealers

The test for adverse selection requires that each seller belong to one of at least two types and that a seller's type be known to the market. In this market, sellers may be divided between new car dealers (NCDs) and used car dealers (UCDs).[5] Sellers in the first group maintain, in addition to their used car business, a new car dealership franchise; those in the second group retail used cars only. But the two types differ with respect to the used car business as well. First, they face different retail demand curves. For NCDs, the used car trade acts primarily as a substitute for the new car trade, when economic conditions cause new car purchases to be depressed (1988 economic survey by the National Automobile Dealers' Association [NADA]). When the purchase of a new car seems prohibitively costly to their customers, NCDs will offer them a used car instead. Thus NCDs are likely to specialize in those used cars that are close substitutes for new cars.

Columns 1–3 of table 1 show the distribution of consumer purchases of used cars by model year and type of seller from a December 1979 national telephone survey.[6] Nearly 60 percent of NCD used cars sold are no more than 4 years old (1976–79), whereas only 30 percent of UCD sales fall into this category. Only 10 percent of NCD cars sold are more than 7 years old; a third of UCD cars sold are this old. For comparison, column 3 provides the model year distribution for private sellers. The hierarchy of markets is clear: NCDs specialize in late-model cars, UCDs sell cars that are 2 or 3 years older, and the oldest cars are left to the private market.

Second, NCDs and UCDs differ in the composition of trade-ins

[5] Large-fleet owners sell their cars in a separate lane and are not included in the auction sample. The validity of the empirical test requires that seller types do not differ, a priori, according to the distribution of the unobservable attributes of the car, whereas it is likely that rental and company fleet cars are driven and maintained differently from consumer-owned cars.

[6] Details of the survey methodology are given in Bureau of Social Science Research and Seznowitz (1982). The survey was undertaken on behalf of the FTC.

TABLE 1

DISTRIBUTION OF CONSUMER PURCHASES AND TRADE-INS OF USED CARS IN 1979

	Consumer Purchases			Consumer Trade-ins			
Model Year	NCD (1)	UCD (2)	Private (3)	NCD (4)	UCD (5)	NCD* (6)	UCD* (7)
1979	7.46	1.34	1.34	3.00	2.56	−1.49	.47
1978	18.81	9.40	5.34	7.83	.00	−1.40	...
1977	14.63	9.40	5.53	11.52	5.13	−.27	−.80
1976	19.10	11.41	6.11	12.90	5.13	−.48	−1.12
1975	10.45	11.41	5.73	11.52	5.13	.09	−1.12
1974	10.15	8.72	11.83	11.75	17.95	.14	.51
1973	8.06	16.11	9.54	12.90	15.38	.38	−.05
1972	3.88	12.08	8.59	10.60	15.38	.63	.21
1971	2.69	6.71	7.25	6.45	10.26	.58	.35
1970	2.09	4.03	8.40	3.23	2.56	.35	.39
< 1970	2.71	9.39	31.33	8.30	21.52	.67	.56
Total	100.00	100.00	100.00	100.00	100.00		
Number	335	149	524	439	39		

* Col. 6 is 1 − (col. 1/col. 4); col. 7 is 1 − (col. 2/col. 5).

received from retail customers. As columns 4 and 5 show, trade-ins to NCDs are concentrated among the late-model cars, and trade-ins to UCDs among the older cars. A third of trade-ins that NCDs receive, but only 13 percent of those that UCDs receive, are no more than 4 years old.

Which type of dealer is more disposed to sell in the wholesale market? If all cars were ultimately obtained from consumer trade-ins and then retailed to consumers, and the size of a dealer's trade-in stock were equal to his retail trade, then the amount of net wholesale sales would simply be the difference between trade-ins and retail sales. Expressed as a percentage of trade-ins received, net wholesale sales for NCDs and UCDs are shown in columns 6 and 7, respectively. (Negative values indicate net purchases.) These figures suggest that both dealer types are net buyers of late-model cars from the wholesale market,[7] but whereas UCDs are net buyers of older cars as well, NCDs are net sellers of these cars. Thus both types are on the same side of the market for late model years but on opposite sides for early model years. This suggests that the behavior of the two types will differ more for older cars. Given the small sample size of purchases and

[7] No adding-up constraint is violated here. All dealers are net purchasers of late-model cars from the fleet companies and net sellers of much older cars to non-U.S. consumers.

TABLE 2

TRADE-INS RECEIVED ANNUALLY (Dealer Survey)

Size of Retail Sales (Used Cars)	NCD	UCD
< 100 cars	3	34
100–300	19	5
300–600	14	1
> 600	6	0
Total	42	40

trade-ins for UCDs, it is difficult to be more conclusive than that. I shall be able to say more with dealers' responses to questions about their propensity to sell on the wholesale market, which are presented in Section VI.

Third, NCDs and UCDs differ in the source of their used cars. In the FTC survey, consumers traded in 39 cars to UCDs but purchased 149 cars in return. Even if all trade-ins were retailed by the dealer who received them and not sold wholesale, trade-ins could therefore account for no more than 26 percent of UCDs' retail stock. Some automobiles are obtained from one-sided sales by consumers to dealers, and the FTC reports 30 such sales to UCDs.[8] The remaining 54 percent of UCDs' retail stock must come from firms, whether as trade-ins or in one-sided sales, or wholesale purchases, whether directly from other dealers or through brokers or auctions. In contrast, NCDs obtain 69 percent of their used car stock from trade-ins (1988 NADA economic survey).[9]

Finally, NCDs typically have a larger used car business. As table 2 indicates, 85 percent of UCD respondents in the dealer survey claimed yearly trade-ins of fewer than 100 cars; only one of 40 reported more than 300 cars. In sharp contrast, only 7 percent of NCDs reported receiving fewer than 100 cars, whereas 45 percent had more than 300 trade-ins. Supporting evidence comes from the 1987 Retail Census, which reports that all NCD, but only a third of UCD, establishments had employees. Of those UCDs with employees, the aver-

[8] Such sales are undercounted since dealers, when purchasing from consumers who have placed newspaper ads, will often not reveal themselves as professionals. However, dealers who engage in such "curbstoning" are generally unlicensed (Jenny King, *Automotive News*, various issues) and thus ineligible to trade at the auction.

[9] They receive 52 percent on sales of new cars and 17 percent on used. The remaining sources are auctions, both dealer consignment and fleet sales (12 percent), brokers' wholesale (8 percent), street purchases (7 percent), and company cars (4 percent).

age number was 3.7, compared to 33.2 for NCDs. The lack of a new car trade for UCDs explains part of this. Yet the used car trade accounts for 40 percent of NCDs' retail unit sales (Wards) and 22 percent of their sales (NADA). If employees are apportioned according to unit sales, the average NCD would have 13.3 employees in its used car business and, if according to dollar sales,[10] 7.3. Furthermore, while the Retail Census reports one and a half as many UCDs as NCDs, more than twice as many respondents in the FTC study reported purchasing their used car from an NCD as from a UCD.

Thus NCDs and UCDs differ in the model year composition of both their retail trade and their trade-in stock, the source of their retail stock, and the size of their trade. Of these, the last is unlikely to have much of an effect on the degree of adverse selection. The source of the retail stock is surely important: if the wholesale market is tainted by adverse selection and UCDs, denied the trade-ins of new car purchasers, purchase mostly from this market, then the wholesale buyer might not unreasonably surmise that a car offered by a UCD will have originated there and therefore will be of inferior quality. This is reason enough to suspect that UCDs will receive a lower price on the wholesale market. But I have no information on the relative importance of the wholesale market as a source of used cars by model year. For this reason, the model sketched below focuses on the relative composition of the retail demand and trade-in stocks.

V. Theory

A dealer receives a stock of used cars in trade-ins. There are a finite number of types into which a car may be classified according to its observable attributes. Consider one such type.

Cars may be either *sold* at the auction or *retained* for retail sale to consumers. Quality is observable by the final retail consumers, but not by bidders at the auction. Consumer demand for cars is inelastic, such that the dealer may sell up to r cars of the given type to consumers but no more. The return to the dealer of holding a car with the intention of selling to a consumer is its quality, if the dealer is not already overstocked in cars of that type. Otherwise, the return is zero. The dealer's optimal behavior is the following: sell any car whose quality is less than the wholesale auction price; if the number of remaining cars exceeds r, sell the excess, selecting the worst among these as well.

[10] The second measure understates the difference between NCDs and UCDs by apportioning all the UCD employees to the used car business and none to parts and services, which makes up 13 percent of NCDs' sales (NADA).

Bidders are assumed to know the average quality of cars offered by each type of seller at the auction. They value exactly as sellers do: a car is worth its quality if the bidder is understocked in that car, and zero otherwise. The expected value of a car to a bidder is therefore either zero or the average traded quality; as the winning bid is determined by the valuation of the second highest bidder, for a large number of bidders the winning bid will be the average traded quality.

In equilibrium, price equals the average quality forthcoming at that price:

$$P_i = \frac{\int E\{z|F(z) \leq \omega\}\omega dG_i(\omega)}{\int \omega dG_i(\omega)}, \quad i = \text{NCD, UCD,} \tag{1}$$

where $\omega \equiv \max\{F(P_i), (S - r)/S\}$, S is the common size of the trade-in stock, F is the quality distribution of trade-ins, and G_i is the (equilibrium) distribution of ω. It is nondegenerate because, among dealers of a given type, the need for stock management, represented by $(S - r)/S$, varies. The equilibrium prices will differ between the two types because the distribution of stock management needs differs between them. By (1), new car dealers will obtain a premium (discount) if and only if they sell a higher (smaller) proportion of their trade-ins wholesale.[11]

In the absence of stock management, dealers would sell only to take advantage of bidders' ignorance. No equilibrium could then exist, for it is impossible, simultaneously, for buyers to pay according to the average quality offered and sellers' offered quality to be all of value less than the buyers' payment. For there to be an equilibrium, there must be some other motive for trade; buyers must value the good more than sellers do. In models of financial markets under asymmetric information, equilibrium is assured by liquidity traders, who value holding stock less than others do. In Gibbons and Katz (1991), workers acquire firm-specific capital. Here I assume that car dealers can sell only a limited number of cars of a given type. Since the composition of trade-ins does not perfectly match the composition of the retail trade, "excess" trade-ins are valued less by the dealer than by the market.

With stock management, an equilibrium is ensured.[12] There is no

[11] In general, one needs to know G_{NCD}, G_{UCD}, and the shape of F to predict the sign of the NCD premium. The survey of car dealers provides us with the first two; the last is unnecessary when G_{NCD} weakly stochastically dominates G_{UCD}, as the next section shows to be true.

[12] Say that quality is distributed on $[l, h]$. When price equals l, some dealers still sell in order to manage their stock, so average traded quality exceeds l. Conversely, when price equals h, selling wholesale dominates the option of retaining the car for sale to consumers. So dealers sell all their cars there, and average traded quality is less than h. Under the appropriate continuity assumptions, an equilibrium must exist.

guarantee that it is unique. However, the test for adverse selection does not require uniqueness. It examines the structural relationship between price and the proportion of trade-ins sold wholesale, given in (1), which must hold whatever the equilibrium.

VI. A Survey of Automobile Dealers

This section reviews a brief survey of automobile dealers listed in the Yellow Pages of communities within a 150-mile radius of the auction. The questionnaire was mailed to 362 dealers, of whom 153 were NCDs and 209 were UCDs. Thirty surveys were returned undelivered: eight from NCDs and 22 from UCDs. Of the remaining dealers, 83 responded in part or in full. Of the respondents, 43 were NCDs and 40 UCDs, so that the response rate of dealers who actually received the survey was 30 percent for NCDs and 21 percent for UCDs.

The questionnaire asked the dealers to indicate the proportion of their trade-ins they sold on the wholesale market, by model year. "Wholesale" was defined in the questionnaire as sales to "other dealers, auctions, [and] wholesalers." Table 3 aggregates the responses. These numbers incorporate the answers of all respondents, including those who provided answers for certain model years only. The presumption is that those who did not indicate a proportion for a certain model year received no, or few, trade-ins of that vintage.[13]

Table 3 suggests that the NCD distribution (weakly) stochastically dominates the UCD distribution for all model years older than 1988. That is, for model years 1984–87 and pre-1984, a higher fraction of NCDs than UCDs reported selling any given proportion *or more* of their trade-ins wholesale.

A second feature of the data is the increasing disparity between the NCD and UCD distributions with the age of the car. This is most evident in the proportion of dealers who sell less than 20 percent of their trade-ins wholesale. In every model year, a higher fraction of UCDs than NCDs fall into this category. But the difference between the two is greater with each year: from 2 percent for 1988 cars to 40 percent for pre-1984 cars. Chi-squared tests (with four degrees of freedom) for the homogeneity of the two samples are reported in column 8 of table 3. The test fails to reject rather dramatically for 1988 and 1987, yields a p-value between .6 and .7 for 1986, and strongly rejects for 1985 and older.

Third, within each type and for the most part, the later model year

[13] With one exception, those who failed to answer certain questions did so for a range of years only, providing answers for the late- but not the early-model cars or vice versa. This pattern suggests the interpretation given to missing responses.

TABLE 3

PROPORTION OF TRADE-INS SOLD WHOLESALE

Model Year	Dealer Type	.0–.19 (1)	.20–.39 (2)	.40–.59 (3)	.60–.79 (4)	.80–1.0 (5)	n (6)	Mean (7)	χ^2 (8)
1988	NCD	27	7	1	3	4	42	26.2	
	UCD	16	3	1	0	4	24	27.5	2.7
								(−.19)	
1987	NCD	21	13	1	3	4	42	29.0	
	UCD	15	8	0	0	3	26	25.4	2.7
								(.56)	
1986	NCD	15	15	7	4	2	43	32.8	
	UCD	17	8	2	1	1	29	23.1	4.5
								(1.82)	
1985	NCD	7	12	12	8	2	41	43.2	
	UCD	15	7	8	0	1	31	27.4	12.2
								(3.00)	
1984	NCD	4	9	10	7	10	40	55.0	
	UCD	17	6	4	2	2	31	28.1	18.4
								(4.30)	
Pre-1984	NCD	3	3	4	12	18	40	69.5	
	UCD	16	3	5	4	6	34	38.8	18.6
								(4.56)	

NOTE.—The t-statistic for the difference in the means is in parentheses. χ^2 is the chi-squared test with four degrees of freedom.

distributions stochastically dominate the earlier ones. Dealers of both types are retaining a higher proportion of their late-model trade-ins than early-model trade-ins. This is not surprising, given the large supply of late models from fleet owners, particularly the rental car companies.

Fourth, it is clear that the growing difference between the distributions of the two types is attributable more to changes in the NCD distribution across model years than to changes in the UCD distribution. Between the 1988 model year and pre-1984, the fraction of UCDs selling less than 20 percent of their trade-ins wholesale is cut by a third, but that of NCDs by almost 90 percent. Similarly, while the fraction of UCDs selling 80 percent or more of their trade-ins wholesale is little changed between these two model years, the fraction of NCDs in this bracket increases fivefold.

The mean proportion of trade-ins sold wholesale, calculated under the assumption that the proportion is distributed uniformly within the brackets, is reported in column 7 of table 3. For UCDs, it bears a U-shaped relationship with age. For NCDs, it clearly increases with the model year. The *t*-statistic for the difference in the means is insignificant for 1988 and 1987 but is significant for 1986 and strongly significant for the remaining years. Employing the median as the measure of location requires no auxiliary distribution assumption. For every model year, at least half of the UCDs report a sale proportion of no more than .2. The median for NCDs, though for 1988 and 1987 also estimated as less than .2, clearly increases with the age of the car, so that by the pre-1984 distribution it lies somewhere between .6 and .8.

To summarize: First, NCDs sell a higher proportion of their trade-ins on the wholesale market than UCDs do; second, for both dealer types, the older the car, the greater the propensity to sell it on the wholesale market; and third, this proportion grows much more quickly with age for NCDs, so that the difference between the two types increases with the age of the car.

The prediction for wholesale prices is therefore (1) that NCDs receive a higher price for model years 1984 and 1985, (2) that among these model years the premium increases with the age of the car, and (3) that both dealer types receive the same price for 1988 and 1987 cars.

VII. Prices from a Wholesale Auto Auction

To test these predictions, the winning bids on 893 automobiles consigned for sale at an auto auction were gathered in the summer of

TABLE 4

MEANS (and Standard Errors)

	Full Sample	1988	1987	1986	1985	1984
Sample size	893	34	170	294	218	177
Bid	3,742	6,694	4,641	4,055	3,237	2,414
	(2,029)	(3,685)	(1,869)	(1,817)	(1,653)	(1,174)
LNBID	8.07	8.67	8.36	8.20	7.93	7.65
	(.60)	(.53)	(.43)	(.49)	(.61)	(.58)
Red Book	6,018	9,304	7,289	6,479	5,496	4,041
	(2,432)	(3,228)	(2,121)	(2,197)	(2,040)	(1,505)
LNRBOOK	8.62	9.09	8.85	8.72	8.54	8.24
	(.42)	(.31)	(.29)	(.33)	(.39)	(.37)
NCD	.14	.12	.07	.14	.17	.16
ONE-OWNER	.16	.06	.12	.18	.17	.18
Mileage:						
MILES	58	35	50	55	64	69
	(20)	(21)	(20)	(19)	(17)	(16)
LNMILES	3.98	3.33	3.82	3.94	4.11	4.20
	(.44)	(.75)	(.48)	(.40)	(.30)	(.27)
MILES100	.06	...	.02	.04	.10	.09
Condition of sale:						
AS-IS	.12	.12	.12	.12	.10	.14
LISTEN	.08	.12	.12	.12	.02	.05
TITLE	.08	.06	.04	.10	.12	.07
SOLD	.59	.41	.52	.61	.56	.68

1989.[14] Characteristics of the car as well as the condition of sale and the auctioneer's comments were also recorded.

Table 4 reports the means of the variables. The average winning bid is $3,742. Given the great number of different models sold at the auction, constructing a hedonic in the usual fashion is infeasible. Instead, the car's make, model, body style, and model year are matched to the appropriate "average wholesale value" in the *Automobile Red Book*. At $6,018, the average *Red Book* value is clearly much larger than the average winning bid. The difference reflects the publisher's "estimated reconditioning costs" necessary to make the car "ready for resale" (to consumers).

Thirteen and a half percent of the cars were declared as offered by a "new car dealer," either announced by the auctioneer or chalked on the rear or side windows of the car. Note that the theory predicts that cars may fetch a different price according to the identity of the seller, only when the buyer can condition on the seller's identity. The

[14] Cars of vintage as old as the 1970s were consigned at the auction. I restricted my attention to those sold through two specific lanes and, thus, model years 1984–88.

variable of interest is therefore not cars sold by NCDs, but cars *known* to be sold by NCDs, and this is what I measure here.

"One-owner car" is likewise either declared by the auctioneer or written on the window, and indicates that the consumer who traded in the car was the original owner. It is likely that there is some measurement error here, for it is difficult to believe that only 6 percent of 1988 cars had had only one previous owner. Possibly "one-owner car" status is taken for granted for very late model cars.

The variable MILES is the number of miles (in thousands) on the odometer. Because many cars cannot report mileage beyond 99,999 miles, all cars with mileage beyond this must be so declared. For such cars, MILES100 take the value one and LNMILES (the logarithm of miles) is set equal to zero; otherwise MILES100 is set equal to zero.

The variables AS-IS and LISTEN refer to the arbitration system under which the car is sold and are mainly determined by model year and the physical condition of the car, for the auction insists that cars with serious defects be sold under these less inclusive systems (AS-IS is the less inclusive system). The variable TITLE indicates that the seller does not have the title to the car on hand (usually because it is being held by a financing company that has a lien on the car [Thomas 1987]) but is committed to making it available to the buyer within a few days' time.

VIII. Estimating the NCD Premium

Table 5 presents estimates from the regression of the log winning bid on car attributes. Although I argue that the premium on an NCD car should differ by the model year, it is nonetheless instructive to see what restricting the premium to be equal across all years would imply. Column 1 indicates that new car dealers obtain a 3 percent increase over used car dealers, or about $115 at the mean price. But the coefficient is insignificant.

It is interesting to note that the increment received for a one-owner car is 9 percent ($330 at the mean price) and is significant at the 1 percent level. This may itself be an indication of adverse selection in the *retail* used car market. Call the average quality of cars sold in period 1 Q. As the quality of cars retained by consumers in that same period will exceed Q, so will the quality of one-owner cars offered in the second period. But the twice-sold car will be adversely selected from cars sold in the first period and so will have an average quality less than Q. Thus the quality of a one-owner car will exceed that of a twice-sold car. The argument is developed for the labor market in greater detail in Greenwald (1986).

The remaining variables have the expected signs. The coefficient

TABLE 5

ORDINARY LEAST SQUARES ESTIMATES

Dependent Variable: LNBID

	1	2	3
Intercept	−1.35	−1.31	−1.34
	(.30)	(.30)	(.30)
LNRBOOK	1.18	1.17	1.18
	(.03)	(.03)	(.03)
NCD	.03		
	(.04)		
NCD × 1988		.10	.10
		(.17)	(.17)
NCD × 1987		−.08	−.09
		(.10)	(.09)
NCD × 1986		−.02	−.01
		(.06)	(.06)
NCD × 1985		.04	.004
		(.06)	(.07)
NCD × 1984		.17	.14
		(.07)	(.08)
ONE-OWNER	.09	.09	
	(.03)	(.03)	
ONE-OWNER × 1988			.11
			(.24)
ONE-OWNER × 1987			−.05
			(.08)
ONE-OWNER × 1986			.06
			(.06)
ONE-OWNER × 1985			.16
			(.07)
ONE-OWNER × 1984			.15
			(.07)
WEEK	−.006	−.006	−.006
	(.004)	(.004)	(.004)
Order:			
ORDER	.91	.91	.90
	(.30)	(.30)	(.30)
ORDER2	−1.37	−1.38	−1.37
	(.56)	(.56)	(.56)
ORDER3	.58	.59	.58
	(.30)	(.30)	(.30)
Mileage:			
LNMILES	−.21	−.21	−.21
	(.03)	(.03)	(.03)
MILES100	−.94	−.95	−.96
	(.13)	(.13)	(.13)
Conditions of sale:			
AS-IS	−.17	−.16	−.16
	(.05)	(.05)	(.05)
LISTEN	−.10	−.11	−.11
	(.05)	(.05)	(.05)
TITLE	−.04	−.05	−.05
	(.04)	(.04)	(.04)
Model year:			
1988	−.07	−.09	−.09
	(.06)	(.07)	(.07)

TABLE 5 (*Continued*)

	1	2	3
1987	−.01	−.01	−.001
	(.03)	(.03)	(.04)
1985	.002	.01	−.02
	(.03)	(.04)	(.04)
1984	.10	.07	.06
	(.04)	(.04)	(.04)
R^2	.71	.71	.71
Mean squared error	.11	.10	.10

on LNRBOOK differs significantly from one, suggesting that LNRBOOK provides only an imperfect cardinal rating. When another published hedonic (*Automotive Market Report,* 1989) is used instead of the *Red Book* figures, the resulting coefficient is little different (1.16). One possible explanation for the large coefficient is a fixed sum that is incurred whenever a car purchased at the auction is to be subsequently sold to consumers. This might reflect reconditioning or other costs. It is also possible that the (observable) quality-price tradeoff in this particular market differs from that of all markets taken together.

As expected, AS-IS and LISTEN are negative. The estimated negative (though insignificant) sign on TITLE indicates that the additional hassle of transferring the title on some other occasion, or the fear that the sale will fall through, reduces the value of the car to a bidder by more than 4 percent. The variable ORDER is the order in which a car appeared on the date in question and varies from one to 120; ORDER2 is its square, and ORDER3 its cube. Bidding is low at the beginning of the day, when bidders are few, and tapers off at the end, when bidders are leaving, partly to avoid rush hour, and when (according to the auction owners) bidders have already spent their allotted budget ("bought their car or two"). This interpretation suggests that dealers may be credit constrained or that the costs of either storing cars on the dealer's lot or transporting them there are convex. The variable WEEK is a time trend. There is some indication, though statistically insignificant, that prices are falling (by 6 percent over the 3-month period).

Column 2 allows the premium on cars sold by new car dealers to differ across model years. The only year with a significant premium is 1984. As predicted, NCDs obtain a premium on the sale of 1984 cars: an additional 17 percent above other dealers, or $400 at the 1984 sample mean. This implies, in turn, that the deviation of average NCD quality from average trade-in quality ranges from $275 to $892,

or from .61 to .78, as a percentage of the standard deviation of the quality distribution, depending on the assumed shape of that distribution.[15]

The coefficients on 1988 and 1987, in being insignificantly different from zero, are consistent with the predictions generated by the dealer survey as well: since NCDs and UCDs share the same propensity to sell wholesale, they also obtain the same price. However, I also expected NCDs to obtain a premium on 1985 cars, but the coefficient, though positive, is insignificant. There is no significant premium for 1986 cars, for which I was agnostic.

A joint test for both 1984 and 1985 cars can be constructed. The null hypothesis, which corresponds to no adverse selection, is H_0: $\phi_{1984} = \ldots = \phi_{1988} = 0$, where ϕ_y is the coefficient on the dummy variable indicating a car of model year y that is offered by an NCD. The alternative, corresponding to adverse selection and the results of the dealer survey, is H_1: $\phi_{1984} \geq 0$, $\phi_{1985} \geq 0$, $\phi_{1986} = \phi_{1987} = \phi_{1988} = 0$. The p-value of the likelihood ratio statistic is .11, indicating a weak rejection of the null of no adverse selection, at best.[16]

The estimated coefficients on the NCD variables exhibit an interesting pattern: except for 1988, for which I have a scant 34 cars, the coefficient is strictly increasing in the age of the car. This was expected from the increasing difference in the NCD and UCD distributions in the dealer survey.

In column 3, one-owner status is likewise interacted with model year. Although the original restriction of no interaction cannot be rejected (p-value of .25 for the F-test), the estimates are interesting nonetheless. There is a large and statistically significant premium not only for 1984 (16 percent) but for 1985 (15 percent) as well. It is clear that at least part of the 1984 NCD premium in column 2 was the result of omitting the ONE-OWNER × 1984 variable. That variable included, the NCD premium for 1984 cars is reduced from 17 percent to 14 percent, now significant at the 7 percent level only. The pattern associated with the new car dealer variable is repeated here:

[15] Equations (1) are easily solved for unknown location and scale parameters of F, given dealer-specific prices and the propensity to sell wholesale distributions. (I assume that S is distributed independently of r, as is broadly consistent with the data.) The calculated absolute deviations are \$275, \$421, \$513, and \$892; as a fraction of standard deviation, they are .76, .77, .78, and .61, assuming that the distribution of negative quality is exponential and that the distribution of quality is normal, uniform, and exponential, respectively.

[16] Gouriéroux, Holly, and Monfort (1982) show that the distribution of the likelihood ratio statistic is a mixture of chi-squares: $\text{prob}\{LR \geq c\} = \Sigma_{i=1,2} \text{prob}\{\chi^2(i) \geq c\} w(i, 2, \mathbf{A})$, where $\chi^2(i)$ is chi-squared with i degrees of freedom and $w(i, 2, \mathbf{A})$ is the probability that i components of a multivariate normal random vector with dispersion matrix $\mathbf{A}$ and mean zero are positive, and $\mathbf{A}$ is the 2 × 2 submatrix of the variance-covariance matrix of the coefficients corresponding to ϕ_{1984} and ϕ_{1985}.

TABLE 6

DIFFERENCE IN MEANS, BY NCD STATUS

	All Years	1988	1987	1986	1985	1984
LNRBOOK	−.03	.39	−.14	−.03	.01	.01
	(.3)	(.07)	(.14)	(.5)	(.9)	(.9)
ONE-OWNER	.39	*	−.04	.49	.45	.44
	(.0000)		(.7)	(.0000)	(.0000)	(.0002)
LNMILES†	.003	−.09	−.19	.001	−.004	.02
	(.9)	(.8)	(.1)	(.99)	(.95)	(.7)
MILES100	.012	‡	*	.04	−.005	−.01
	(.6)			(.4)	(.99)	(.8)
AS-IS	−.01	*	−.04	.04	−.005	−.06
	(.8)	(.5)	(.7)	(.5)	(.9)	(.3)
LISTEN	−.01	*	*	.01	.02	.03
	(.7)			(.8)	(.6)	(.6)

NOTE.—Coefficient is the average for NCD cars minus the average for UCD cars. p-value for the t-statistic of the difference, assuming unequal variances, is in parentheses.

* All NCD cars were coded zero for these variables.

† The sample is restricted to cars with less than 100,000 miles.

‡ No observations.

with the exception again of 1988 cars, the premium for ONE-OWNER increases with age.

A natural suspicion is that new car dealers receive higher prices for 1984 cars because they sell cars of observably better quality, observable to the bidders at the auction, that is, but not recorded in the data. There are two responses to this criticism. First, the pattern of the premiums across model years is predicted by the adverse selection hypothesis, but not by the alternative. Second, table 6, which presents the difference in means by seller type for selected regressors, shows that the recorded attributes are typically uncorrelated with NCD status. The one regressor significantly correlated with NCD status is ONE-OWNER. It falls into the same category as NCD: it has an asymmetric information interpretation and is not definitionally a measure of observable quality. On the other hand, the remaining regressors, in particular AS-IS, LISTEN, and the mileage variables, are all *by definition* measures of observable quality. That they do not vary with seller type suggests that unrecorded observable attributes are likewise uncorrelated with seller type as well and so, by their absence, impart no bias to the estimated NCD premium. Although one might make the same claim for ONE-OWNER as for NCD, that it, too, predicts observable quality, it seems reasonable to suppose that the unrecorded observable attributes would behave more like those attributes that, by definition, measure quality.

Yet another interpretation of the results is that the degree of asymmetry in information is substantial for older used cars only, as in

Grieve (1983), Bond (1984), and Lacko (1986). This might explain why there is no premium on 1985 cars, although the difference between NCD and UCD wholesale behavior is large.This interpretation suggests that a comparison across model years might not provide an appropriate test of the theory; comparison across distinct geographical markets might provide a better test.

IX. Conclusion

The large gap between the average quality of trade-ins and the average quality of cars sold wholesale for 1984 begs the question: Why trade cars in this manner? After all, much of the asymmetry of information is an artifact of the manner of trade. Cars *need not* be traded in a minute and a half. Dealers do trade with each other away from the auction, where, presumably, there are opportunities to more carefully examine the car. Why sell a high-quality car at the auction when you can convince a neighboring dealer of its true value and sell it for its true value? The answer, of course, is that there must be substantial advantage to selling in more liquid markets. After all, there may be no gains from trade between the two neighboring dealers.

Cars could be traded differently at the auction itself. One possibility is that bidders be allowed more time to examine the car at the auction block. Another is that the auction house examine the car and certify the car's quality. There are difficulties with both proposals. The first would necessarily decrease the number of cars that a dealer could bid on at any given visit to the auction. The second would almost surely require the seller to bring the car in a few days before the auction, thus removing it from the lot and possibly causing the dealer to lose a retail sale. Also, it is difficult to see how the auction could deter free-riding on its certification. As it is, buyers and sellers free-ride on the auction's brokerage services by consummating trades on previously consigned cars directly off the auction lot.

Any conclusion about the extent of adverse selection in the wholesale market for used cars must be tentative. Evidence for adverse selection is the premium accorded to the seller type with the higher propensity to sell. I found such a premium for 1984 cars: NCDs are twice as likely as UCDs to sell a 1984 trade-in wholesale and receive a large (though weakly significant) premium in return. Supporting evidence comes from the absence of 1988 and 1987 premiums, for which NCD and UCD wholesale selling behavior is indistinguishable. However, I failed to observe a 1985 premium, though NCDs are one and a half times as likely to sell a 1985 trade-in wholesale as are UCDs.

References

Akerlof, George A. "The Market for 'Lemons': Quality Uncertainty and the Market Mechanism." *Q.J.E.* 84 (August 1970): 488–500

———. "Reply to Professor Heal." *Q.J.E.* 90 (August 1976): 503.

Bond, Eric W. "A Direct Test of the 'Lemons' Model: The Market for Used Pickup Trucks." *A.E.R.* 72 (September 1982): 836–40.

———. "Test of the Lemons Model: Reply." *A.E.R.* 74 (September 1984): 801–4.

Bureau of Social Science Research and Seznowitz, Michael. "A Report on a National Survey of Private Buyers and Sellers of Used Automobiles." Washington: Fed. Trade Comm., September 1982.

Genesove, David. "Search at Wholesale Auto Auctions." Manuscript. Cambridge: Massachusetts Inst. Tech., 1993.

Gibbons, Robert, and Katz, Lawrence F. "Layoffs and Lemons." *J. Labor Econ.* 9 (October 1991): 351–80.

Gouriéroux, Christian; Holly, Alberto; and Monfort, Alain. "Likelihood Ratio Test, Wald Test, and Kuhn-Tucker Test in Linear Models with Inequality Constraints on the Regression Parameters." *Econometrica* 50 (January 1982): 63–80.

Greenwald, Bruce C. "Adverse Selection in the Labour Market." *Rev. Econ. Studies* 53 (July 1986): 325–47.

Greenwald, Bruce C., and Glasspiegel, Robert R. "Adverse Selection in the Market for Slaves: New Orleans, 1830–1860." *Q.J.E.* 98 (August 1983): 479–99.

Grieve, Judith Helen. "Quality Certification in 'Lemons' Markets: An Empirical Investigation." Ph.D. dissertation, Univ. Chicago, 1983.

Heal, Geoffrey. "Do Bad Products Drive Out Good?" *Q.J.E.* 90 (August 1976): 499–502.

Lacko, James. "Product Quality and Information in the Used Car Market." Staff report. Washington: Fed. Trade Comm., Bur. Econ., April 1986.

Thomas, Charles. "The Year in Auctions." *Automotive News* (December 28, 1987), p. E10.

Wilson, Charles A. "The Nature of Equilibrium in Markets with Adverse Selection." *Bell J. Econ.* 11 (Spring 1980): 108–30.

Wolinsky, Asher. "Prices as Signals of Product Quality." *Rev. Econ. Studies* 45 (October 1983): 647–58.

[Footnotes]

[16] **Likelihood Ratio Test, Wald Test, and Kuhn-Tucker Test in Linear Models with Inequality Constraints on the Regression Parameters**
Christian Gouriéroux; Alberto Holly; Alain Monfort
Econometrica, Vol. 50, No. 1. (Jan., 1982), pp. 63-80.
Stable URL:
http://links.jstor.org/sici?sici=0012-9682%28198201%2950%3A1%3C63%3ALRTWTA%3E2.0.CO%3B2-Y

References

Layoffs and Lemons
Robert Gibbons; Lawrence F. Katz
Journal of Labor Economics, Vol. 9, No. 4. (Oct., 1991), pp. 351-380.
Stable URL:
http://links.jstor.org/sici?sici=0734-306X%28199110%299%3A4%3C351%3ALAL%3E2.0.CO%3B2-R

Likelihood Ratio Test, Wald Test, and Kuhn-Tucker Test in Linear Models with Inequality Constraints on the Regression Parameters
Christian Gouriéroux; Alberto Holly; Alain Monfort
Econometrica, Vol. 50, No. 1. (Jan., 1982), pp. 63-80.
Stable URL:
http://links.jstor.org/sici?sici=0012-9682%28198201%2950%3A1%3C63%3ALRTWTA%3E2.0.CO%3B2-Y

LINKED CITATIONS