A Direct Test of the "Lemons" Model: The Market for Used Pickup Trucks

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This note provides an empirical test of one of the implications of models of markets with asymmetric information. In the seminal paper on markets with asymmetric information, George Akerlof (1970) pointed out two possible outcomes that may occur where sellers have better information about the quality of products than do buyers. One possibility is that bad products will drive out good products. If buyers cannot distinguish quality until after the purchase has been made, there will be no incentive for sellers to provide good quality products, and the average quality in the market will decline. In the case of cars, an often-cited example of this phenomenon, owners who discover that they have a "lemon" will attempt to sell it in the used car market to an unsuspecting buyer. The owner of a "creampuff" will not sell his car, since it is indistinguishable from a lemon to buyers and must therefore sell for the price of a car of average quality. The effect of quality uncertainty is to reduce the volume of transactions in the used car market below the socially optimal level.

A second possibility suggested by Akerlof is that institutions may develop to counteract the effects of quality uncertainty. Warranties and brand names can be used to give the buyer some assurance of quality. These institutions may prevent good products from being driven from the market, but they will not necessarily eliminate the inefficiency. These institutions may be costly, and sellers may overinvest in signalling the quality of their product to buyers (for example, see Akerlof, 1976).

The purpose of this note is to test whether bad products drive out good products in the market for used pickup trucks, a market similar to the used car market. The measure of quality chosen here is the amount of maintenance required on a truck, with a lemon being a truck that requires significantly more maintenance than average. Owners will have an idea of the truck's quality from past maintenance experience, but it may be difficult for a potential buyer to predict future maintenance from inspecting the truck. If this informational asymmetry is significant and counteracting institutions do not develop, the lemons model would predict that owners of high maintenance trucks would sell them in the used market. The used truck market would then become a market for lemons, with the abundance of high maintenance trucks driving out sellers of low maintenance trucks as described above. The empirical implication of this model is that a sample of trucks that has been purchased used should have required more maintenance (since it should contain more lemons) than a sample of trucks with similar characteristics that have not been traded. Section I reports the results of such a test using data from the *1977 Truck Inventory and Use (TIU) Survey*.

The results indicate that if the effects of age and lifetime mileage on maintenance are controlled for, there is no difference in maintenance between trucks acquired new and trucks acquired used. This leads to a rejection of the hypothesis that bad products have driven out good, since there is no evidence of an overabundance of lemons among used trucks. One explanation for this finding is that the counteracting institutions of the type discussed by Akerlof may have developed. The provision of warranties on used trucks and the seller's concern about his reputation may prevent sellers from supplying low quality products. A second possible explanation is that buyers are able to obtain enough information from search to eliminate the asymmetry. While the finding that the

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average quality of original owner and used trucks is the same is consistent with the operation of an efficient market for used trucks, the market could still be inefficient if the informational asymmetry is eliminated through costly counteracting institutions or costly search by buyers.

I. Testing the Lemons Model

As discussed above, the hypothesis that the used truck market contains an overabundance of lemons was tested by comparing the frequency of maintenance between trucks that were acquired used and those that were acquired new in the *TIU Survey*. This section describes the data obtained from the *TIU Survey* and reports the results of the test.

The *TIU Survey* is part of the Census of Transportation. It is based on a stratified probability sample of all trucks registered at motor vehicle departments in the fifty states, and requests information about the characteristics and usage of the trucks. With regard to maintenance, respondents were asked whether their truck had required major maintenance in any of five categories (engine, transmission, brakes, rear axle, and other) in the preceding twelve months.[1] Since the maintenance variable is a dichotomous variable, the frequency of maintenance of a given type in a sample of trucks can be modeled with a binomial distribution if the trucks in the sample are similar. The *TIU Survey* contains information on model year and lifetime mileage, so that it is possible to control for the effects of these observable factors on maintenance. If these factors are controlled, the sample proportion will be an estimate of the probability of maintenance among trucks of that type.

Pickup trucks were selected for study because pickup trucks have the largest noncommercial demand of any trucks in the survey. In the sample, 59 percent of the pickups are used for personal transportation, 21 percent are in agriculture, and the remainder are in various commercial uses (primarily construction, services, and retail trade). It was felt that the large household demand would increase the likelihood of asymmetric information in secondhand markets, since one would expect that household purchasers have less expertise in evaluating used trucks than commercial purchasers.

In addition, several other bits of evidence suggest similarities with the automobile market. Pickup trucks are produced by the major automobile producers (both foreign and domestic), and are sold by many car dealers. The retail markup over dealer cost on a pickup is comparable to that of a full-size car. Finally, the frequency of trading of pickups is comparable to that of autos. Of the trucks purchased during 1976, 60 percent were purchased used. Although data for the same year are not available for automobiles, the 1972 survey of household durable purchases (Department of Commerce, 1973) indicates that 65 percent of automobiles purchased in that year were used.

One question that had to be addressed was the choice of model years to study. Enough time must be allowed for owners to become aware that their trucks are lemons, but if the model year studied is too old, many of the lemons may already have been scrapped.[2] Since the lemons model gives no guidance on this point, trucks that were from one- to five-years old in 1977 (model years 1972–76) were studied to give a fairly wide range of time for the lemons effect to occur.

Table 1 shows the number of pickups in the survey, the percentage acquired used, and the proportion of new and used trucks that required major engine maintenance for each model year. The proportion requiring maintenance is slightly higher for used trucks in three of the years. However, this comparison is biased against used trucks since used trucks had significantly higher lifetime mileage in each model year.

[1] It would be preferable to have information on actual maintenance expenditures, since the quality depends not only on the probability of maintenance but also on the costliness of repairs. Unfortunately, expenditure data were not available. However, the costliness of repairs will be partially captured by the fact that the respondents are asked only to indicate major maintenance.

[2] The median age of pickup trucks in the *TIU Survey* was 7 years. By the time trucks were five years old, more than 50 percent had been traded at least once.

TABLE 1—SUMMARY STATISTICS OF THE SAMPLE

Year	Number in Sample	Acquired Used	Proportion Requiring Engine Maintenance	
			New	Used
1976	2137	.11	.08	.05
1975	1602	.27	.10	.11
1974	2261	.37	.11	.13
1973	2085	.48	.15	.15
1972	1839	.53	.13	.15

TABLE 2—TESTS OF DIFFERENCES IN PROPORTIONS REQUIRING MAINTENANCE

	Number of Tests	Used Inferior (10 percent level)	Used Superior (10 percent level)
1976	19	1	2
1975	27	0	2
1974	44	2	3
1973	57	3	1
1972	67	2	1

If the lemons hypothesis is true, the probability of maintenance should be higher for secondhand trucks than for trucks with similar characteristics that were acquired new. The effects of observable characteristics were controlled for by grouping trucks according to model year and lifetime mileage. Let P^n_{ijk} be the probability of maintenance of type i for trucks of model year j and mileage group k that were acquired new, and let P^u_{ijk} be the corresponding proportion for trucks acquired used. The first test of the lemons model was to test the null hypothesis of no difference in quality between trucks acquired new and trucks acquired used, $P^n_{ijk} = P^u_{ijk}$. If the number of observations is large enough, the difference in group means will be normally distributed. Due to the low frequencies of several types of maintenance and the small number of used trucks in the 1975 and 1976 model years, larger mileage groupings had to be chosen to make the assumption of normality for those years.[3]

The advantage of the test for equality of individual group means is that it allows testing of the hypothesis that only some segments of the market operate inefficiently. For example, suppose that the unreliability of service and large amount of down time associated with operating a lemon precludes its being used very intensively. A buyer of a high mileage truck would then be certain that he was not getting a lemon. If lifetime mileage can be used as a signal for unobservable quality, some portions of the market might not contain lemons.

The results of the tests on group means are reported in Table 2, with the number of groups in which the used trucks were judged to be inferior at a 10 percent level of significance shown in column 2. The results indi-

[3]In order for the binomial distribution to be approximately normal, the expected frequency of maintenance should be at least 5 in each group (see R. Hogg and A. Craig). In order to satisfy this condition, it was necessary to expand the size of the mileage groups for the more recent model years (where relatively few trucks were used) and for transmission and rear axle maintenance (which were more rare events). For the 1972–74 data, the mileage groups were in intervals of 10,000 miles for most maintenance tests. For the 1975–76 data, the groups had to be expanded to 15–20,000 miles intervals for all maintenance tests except the "other" category.

cate almost no support for the lemons model in any of the model years. In fact, equally strong support could be found for the hypothesis that trucks in the used market are superior (shown in column 3). There was no evidence that the cases where used trucks were inferior were concentrated in any particular segment of the market.

The data indicated that the probability of maintenance generally increased with the lifetime mileage of the truck, as one would expect.[4] Since maintenance is a dichotomous variable, the relationship between maintenance and mileage can be estimated using a logit model:

$$(1) \qquad ln[P_i/(1-P_i)] = \alpha_i + \beta_i x + \varepsilon,$$

where P_i is the probability of maintenance of type i and x is lifetime mileage. A second test of the lemons model was performed by estimating (1) separately for both used and original owner trucks, and then testing whether the slope and constant terms were equal for the two equations. This provides an overall test of whether used trucks and original owner trucks have any difference in quality.

The presence of a market for lemons would be indicated by a constant term in the equation for used trucks that was significantly greater than that for trucks acquired new, or by a combination of differing slope and constant terms that indicate greater maintenance for used trucks over the relevant range. The model was estimated by grouping the data by mileage for both new and used trucks, and then using the group means to estimate (1) with the weighted least squares approximation to the logit discussed by D. R. Cox. Equations were estimated for all five types of maintenance for model years 1973 and 1975. In none of the equations were either the slopes or constant terms significantly different at the 5 percent level between original owner and used trucks. This test provides further support for the hypothesis that there is no dilution of quality in the used market.

[4]An exception to this was maintenance in the "other" category, which was negatively related to lifetime mileage.

II. Conclusion

The main finding of this note is that trucks that were purchased used required no more maintenance than trucks of similar age and lifetime mileage that had not been traded. This leads to a rejection of the hypothesis that the used pickup truck market is a market for lemons, which would have required used trucks to show significantly more maintenance. However, it should be noted that the failure to find an overabundance of lemons in the used market is not inconsistent with the commonly expressed notion that cars and trucks are traded when they become "too costly" to maintain. Suppose that there are two types of buyers in the market: one group with high maintenance costs and a second group of handymen with low maintenance costs. As trucks age and require more maintenance, high maintenance cost owners will prefer to sell to low maintenance cost buyers rather than to continue to operate the truck themselves.[5] While it might appear to members of the former group that used trucks are too costly to maintain, this results not from the existence of a market for lemons, but from the reallocation of the stock of assets to those individuals who value them most highly.

[5]A complete model of used asset markets with complete information and different types of consumers is presented in my working paper, which also presents evidence that buyers who do their own maintenance are more likely to buy used trucks.

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