ASYMMETRIC INFORMATION AND LEMONS HYPOTHESIS: FURTHER EVIDENCE FROM THE U.S. DATA

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ABSTRACT

This study uses a modified version of Bond's (1982) lemon model to test the quality of traded and non-traded cars in the market. To deal with the censoring problem in the data, a tobit model is used and sensitivity analysis is applied to check the robustness of the coefficients. The data is collected from the Panel Study of Income Dynamics (PSID) from the University of Michigan for this study. The results show that the average quality of traded cars is not significantly different than that of non-traded cars, all else equal, indicating that traded cars required same maintenance expenditures as non-traded cars of a similar age. **JEL Classification:** D82, D91, L15

INTRODUCTION

Adverse selection can cause inefficiency in the functioning of a market as suggested by Akerlof (1970) in his seminal paper on the lemons market. Because of asymmetric information between buyers and sellers of cars, sellers of good cars are willing to sell their cars at a certain price, not below that price. But buyers are not willing to buy cars of average quality at that price, because they are unable to discern lemons from good cars. The presence of sufficient amount of bad cars in the market pushes the price down below that certain price, which in turn drives the good cars out of the market. When the good cars are driven out of the market, the average quality of the remaining cars in the market fall, and this further lowers the price that buyers are willing to pay. This process of driving out the good cars may lead to a point where there is no trade in the market: "the bad cars tend to drive out the good" as suggested by Akerlof (1970). By assuming a positive volume of trade, Wilson (1980) showed a nontrivial equilibrium in the used car market. Thus, the lemon hypothesis can be reinterpreted as saying that the average quality of non-traded cars is higher than that of traded cars. In the used car market context, Akerlof (1970) suggested that in this situation private institutions can emerge in order to provide information to buyers about the quality of cars, and these institutions can improve the functioning of a market, but they may not be able to eliminate market failure completely caused by asymmetric information.

The role of leasing was examined by Gilligan (2004), and he found evidence that leasing mitigates the consequences of asymmetric information about the quality

uncertainty of used durable goods. Hendel and Lizzeri (2002) showed that the turnover of off-leased cars is higher than that of other used cars; implying leasing contracts can improve inefficiency caused by asymmetric information. Johnson and Waldman (2003) showed that leasing reduces the adverse selection problem. Further evidence was provided by Aizcorbe and Starr-McCluer (1997), and Starkey (1997); they found that the higher income consumers prefer leasing to buying. Desai and Purohit (1998) also found that off-leased cars are of higher average quality than other used cars. Offer (2007) examined automobile depreciation rates and dealer markups in the United States and Britain to provide evidence on the effect of asymmetric information on market structures and found weak evidence of lemons hypothesis. Johnson and Waldman (2010) constructed and analyzed a model of the new and used car markets that incorporates both adverse selection and moral hazard and showed that leasing mitigates adverse selection.

Leasing in the automobile industry has been growing rapidly in the last 20 years. For example, consumer leasing as a percentage of the number of cars acquired was 9.3 percent in 1992, which increased to 20 percent in 2002, and it further went up to 22 percent in 2010 (see CNW Marketing/Research). Most car leases are two to three years long, and studies show that only 25 percent of lessees keep their cars at maturity (see Hendel and Lizzeri [2002]), implying that lessees hold onto their cars for shorter periods than car buyers. In fact, many off-leased cars are still under a manufacturer's warranty at the time they are returned.

Certified Pre-Owned (CPO) programs (see polk.com) aim to refurbish the off-leased vehicles after a multi-step inspection and provide an extended warranty. Most off-leased cars are inspected, refurbished and resold as CPO cars. In recent years, the industry witnessed about a 20 percent increase in sales of CPO vehicles (see Used Car Market Report by Manheim Auctions).

With these changes, the automobile industry is a different market segment now as compared to many years ago. A significant number of off-leased and CPO cars are sold in the used car market. So, the motivation of doing this study is the fact that there might be a different answer to the lemons hypothesis. Thus, the question to examine is this: Is the average quality of non-traded cars still higher than that of traded cars?

The remainder of this paper is organized as follows. Section 2 describes empirical analysis, and section 3 offers brief conclusions.

EMPIRICAL ANALYSIS

Bond (1982) tested the lemons hypothesis (whether the average quality of traded and non-traded cars is the same) by using data from the Truck Inventory and Use Survey of the Census of Transportation with frequency of maintenance as dependent variable while mileage, age of car, and "traded" as independent variables, and he finds no support for the lemons hypothesis. Lacko (1986) finds some evidence of adverse selection by comparing the quality of cars purchased from friends and those that were purchased through newspaper ads. He finds that cars purchased from friends and relatives require less maintenance expenditures than cars purchased through newspaper ads. Comparing prices of cars that are sold by New Car Dealers (NCDs) and Used Car Dealers (UCDs) at the wholesale auctions, Genesove (1993) finds that NCDs receive premium over UCDs for the cars of same model and quality, implying

weak evidence of adverse selection. Pratt and Hoffer (1986) investigated whether the quality certification and the used vehicle disclosure laws required by certain states are effective or not? They find that there is no evidence that the mandated disclosure requirements in certain states are effective in increasing the number of good quality trucks traded in the market.

Data and the Methodology

This study uses the following model, which is an extended version of Bond (1982):

$$M_{it} = \beta_o + \beta_1 (TRADED_{it}) + \beta_2 (AGEC_{it}) + \beta_3 (Demog_{it}) + \beta_4 (VEHICLETYPE_{it}) + \beta_5 (Y_{it}) + \beta_6 (SYEAR_t) + \varepsilon \quad (1)$$

where M_{it} = maintenance expenditure incurred on a car and is computed by dividing maintenance expenditures with number of cars in a household, which is a proxy for the quality of a car; TRADED is a dummy variable equaling 1 if the car acquired was used, and 0 otherwise; AGEC represents age of a car; Demographic factors include sex, age, ethnicity, education, and marital status of head of the household; VEHICLETYPE is a dummy variable equaling 1 if the vehicle acquired was car, and 0 otherwise; Y represents income of the household; and SYEAR is a dummy variable for survey year. This model has more socio-economic variables reflecting on a consumer's choice of vehicle type.

A car requiring more than average maintenance expenditure is considered a lemon, whereas a car requiring less than average expenditure is a good car. The presence of a positive and significant value of the coefficient of TRADED β_1 indicates that a traded car is likely to have more maintenance expenditure than a non-traded car, all else being equal. Alternatively, the presence of a negative and significant value of β_1 indicates that a traded car is likely to have less maintenance expenditure than a non-traded car. If β_1 is insignificant, then there is no significant difference in the maintenance expenditures between a traded and a non-traded car. β_1 is expected to be not significantly different from zero

This study tests the hypothesis of no difference in the average maintenance expenditures required for traded and non-traded cars. The alternative hypothesis is that the average maintenance expenditures required for traded cars is lower than that of non- traded cars. If the null hypothesis is rejected, that implies that the quality of traded cars is better than non-traded cars. The above model is estimated using the Tobit method instead of the OLS method because there are almost half of cars in the sample having zero maintenance expenditure. If the model is estimated using OLS, because of the large number (proportion) of zero maintenance, the estimates will be biased and inconsistent, since there is no guarantee that E(ε) will be necessarily zero. As shown in Table 1, approximately half of the cars in the sample do not require any maintenance expenditure. To deal with this censoring, a Tobit model is estimated because the Tobit model assumes that the structure of the error term as $\varepsilon \sim N(0, \sigma^2)$, where σ^2 is the variance of the error term.

There is a common notion that as a car gets older, more maintenance expenditure it would require. Akerlof's (1970) lemons model gives no specific guidance about how long would it take a car owner to become aware that his car is a lemon. Among the older cars, many of lemons may already have been scrapped. Many newer cars

may still have warranty so age of a car must be controlled for. So, age of the cars is an explanatory variable to take care of the issue.

Variables income, education, ethnicity, marital status, vehicle type, and age of household are also added to the list of explanatory variables as they are also expected to affect the maintenance expenditure incurred on a car, which is a dependant variable.

Four versions of the model are estimated. First, I estimate the model separately for traded and non-traded cars to compare their intercepts and slopes, second, I estimate the model with income and age of household variables, and some other socio-economic variables, third, I add both income and age of household, and squared of these two variables in the model. The variables income squared and age squared are added to see the non-linearity effects between these variables and the dependent variable. This procedure allows us to better understand the effect of these variables on the estimate of car maintenance expenditure. Fourth, I estimate the model for traded cars of age 10 years and above.

Data Description

This empirical analysis draws bi-annual survey data for years 1999 and 2001 from sections V and X and for years 2003 to 2009 from section F of "The Panel Study of Income Dynamics (PSID)" from the University of Michigan. The data about vehicles are taken from sections V and F, while data on maintenance expenditures are taken from sections X and F. These sections have been a part of the survey since 1999. The sample covers total of 40,565 cars for years 1999 to 2009. The households who do not own a car are not included.

Table 1 contains the summary statistics. It shows that the proportion of used cars that required maintenance expenditures is 27.5 percent, while only 17.5 percent new cars required maintenance expenditures. Fifty-eight percent of cars in the sample were acquired used, whereas 42 percent of them were purchased new. Forty-five percent of cars in the sample required any maintenance expenditures.

Descriptive statistics for the data is presented in Table 2. It shows that the average monthly maintenance expenditure for the used car in the household is about 284 dollars, while it is about 270 dollars per month for the new car. The average price of the car acquired new is 18,112 dollars, whereas the average price of used car is 7,149 dollars. Average age of the households who bought new cars is 47.92, 47 percent of them are college graduates, 73 percent of them are white, and their average annual income is 90,202 dollars; while average age of those household who bought used cars is 42.43 and their average annual income is 51,567 dollars.

Discussion of the Results

The results are presented in Table 3. As shown in the table, both traded and non-traded have negative and significant constant terms, but slope of traded is positive, while that of non-traded is negative, implying that non-traded require less maintenance expenditures as compared to traded cars. Column 1 of Table 3 shows that the estimated coefficient of $\beta_1 = 0.001$ ($z = 0.41$) is positive and insignificant as expected implying that there is no difference in the maintenance expenditures between traded and non-traded car of a similar age. In the second column, we show the result by adding squared of both age of household and income variables to the basic model.

As displayed in column 2 of Table 3, the estimated coefficient of TRADED is β_1 = 0.001 (z = 0.44). The estimated coefficient of TRADED is positive and insignificant. This indicates that the average quality of a traded car is same as that of non-traded car.

Next, I estimate the model by taking traded cars of age 10 years and above and find that the estimated coefficient of TRADED 0.004 (z = 1.45) is positive and significant at the 10% level of significance, indicating that the average maintenance expenditures incurred on traded and non-traded car is not the same. This indicates that maintenance expenditure is significantly different for both types of cars – traded and non-traded.

Table 3 also shows that the variables male, white, and high school graduate are positively associated with maintenance expenditures, while the variables age of household, income, marital status, and college graduate are negatively associated with maintenance expenditures, indicating that they prefer new cars.

To test the hypothesis of the stability of parameters, we find the F-Statistic to be 0.931. Thus, the stability hypothesis cannot be rejected at the 10% level of significance, implying strong possibility of pooling. Therefore, the results from the combined data are presented only.

Sensitivity Analysis

Sensitivity analysis is carried out to examine whether the estimates are robust to alternative model specifications. In general, the parameter estimates are robust. In particular, the estimated coefficient for the variable, TRADED remains positive and insignificant.

First, I estimate the model using OLS with different specification choices and find that the results are very similar to the baseline results from Tobit, where the baseline results are displayed in column 1 of Table 3.

Second, I estimate the Tobit and OLS models by adding more explanatory variables and find that the results are still very similar to the baseline results as shown in Table 3. The result shows that the coefficient estimate of TRADED is positive and statistically insignificant. With income and income squared as new explanatory variables, the estimated coefficient of TRADED remains the same.

CONCLUSION

This paper examines the difference in the quality between traded and non-traded cars. The quality of a car is determined by measuring maintenance expenditure incurred on a car. The study finds that traded cars require same maintenance expenditure as non-traded cars, all else equal. This result is consistent with earlier empirical testing by Bond (1982), Lacko (1986), and Genesove (1993). This finding is not consistent with the common perception that the cars are sold when they become expensive to maintain. One possible explanation is the institutions (such as leasing, warranty, and CPO) to counteract quality uncertainty as suggested by Akerlof. Higher income consumers prefer leasing their cars, they off-lease their cars at the expiry of the leasing contract, and these cars are refurbished before selling as CPO cars. Hence, used car market is not overabundanced with lemons as envisaged by Akerlof (1970). However, this is not entirely because of the institutions of leasing, warranty, and CPO. There

are also some other contributing factors such as maintenance level and valuations of consumers for car service. In addition, there are some higher valuation consumers who buy new cars in every period and choose high levels of maintenance in order to get good service from their cars, and they sell them after one period and buy new cars again to continue having good service from their cars. Thus, they supply good quality used cars in the market.

REFERENCES

Aizcorbe, Ana, and Starr-McCluer, Martha. (1997). Vehicle Ownership, Purchases, and Leasing: Consumer Survey Data. *Monthly Labor Review*, 120, 34-40.

Akerlof, George A. (1970). The Market for "Lemons": Quality Uncertainty and the Market Mechanism. *Quarterly Journal of Economics*, 84, 488-500.

Bond, Eric W. (1982). A Direct Test of the Lemons Model: The Market for Pickup Trucks. *American Economic Review*, 72, 836-40.

Desai, P., and Purohit, D. (1998). Leasing and Selling: Optimal Marketing Strategies for a Durable Goods Firm. *Management Science*, 44, S19 – S34.

Genesove, David. (1993). Adverse Selection in the Wholesale Used Car Market. *Journal of Political Economy,* 101, 644-65.

Gilligan, Thomas W. (2004). Lemons and Leases in the Used Business Aircraft Market. *Journal of Political Economy,* 112, 1157-80.

Hendel, I., and Lizzeri, A. (2002). The Role of Leasing Under Adverse Selection. *Journal of Political Economy*, 110, 113-143.

Johnson, J., and Waldman, M. (2003). Leasing, Lemons, and Buybacks. *RAND Journal of Economics*, 34 (2), 247-265.

Johnson, J., and Waldman, M. (2010). Leasing, Lemons, and Moral Hazard. *Journal of Law and Economics*, 53 (2), 307-328.

Lacko, James. (1986). Product Quality and Information in the Used Car Market. *Staff Report*, Federal Trade Commission, April 1986.

Offer, Avner. (2007). The markup for lemons: quality and uncertainty in American and British used-car markets, *Oxford Economic Papers,* 59, i31-i48

Pratt, Michael D., and Hoffer, George E. (1986). The Efficacy of State Mandated Minimum Quality Certification: The case of Used Vehicles. *Economic Inquiry*, 313-18.

Starkey, William. (1997). Automobile Leasing in the United States: Why do Consumers Lease Cars, Ph.D. Dissertation, University of Washington.

Wilson, Charles. (1980). The Nature of Equilibrium in Markets with Adverse Selection. *Bell Journal of Economics*, 11.

TABLE 1: SUMMARY STATISTICS

Variable	Combined Data
Total Cars	40,565
Cars acquired Used (%)	58
Proportion requiring maintenance	
All cars (%)	45
Used cars (%)	27.5
New cars (%)	17.5

TABLE 2: DESCRIPTIVE STATISTICS

Variable	Combined data
Average price of new cars ($)	18,112
Average price of used cars ($)	7,149
Annual average income of households who buy new cars ($)	90,202
Annual average income of households who buy used cars ($)	51,567
Average age of households who buy new cars (years)	47.92
Average age of households who buy used cars (years)	42.43
Monthly average maintenance expenditures incurred on new cars ($)	270
Monthly average maintenance expenditures incurred on used cars ($)	284
Percent of households who are white and have new cars	72.8
Percent of households who are college graduate and have new cars	47

TABLE 3: TOBIT ESTIMATES (COMBINED DATA)

Independent Variable	Traded	Non-traded	Estimated Coefficient (1)	(2)	(3)
Constant	-4.21***	-4.20***	-4.48***	-4.71***	-4.76***
	(3.45)	(3.44)	(3.40)	(3.58)	(3.89)
TRADED	0.0004	-0.004*	0.001	0.001	
	(0.14)	(1.48)	(0.41)	(0.44)	
AGE of a Car	0.001***	0.001***	0.0009***	0.001***	0.001**
	(6.41)	(6.42)	(6.02)	(6.09)	(6.35)
SURVEY YEAR	0.002***	0.002***	0.002***	0.002***	0.002**
	(3.36)	(3.36)	(3.36)	(3.48)	(3.80)
AGE OF HEAD OF HOUSEHOLD	-	-	-0.001***	0.001**	-
			(12.75)	(2.15)	
SEX OF HEAD OF HOUSEHOLD (1 if male, 0 otherwise)	-	-	0.008*	0.008*	-
			(1.60)	(1.56)	
MARITAL STATUS OF HEAD OF HOUSEHOLD (1 if married, 0 otherwise)	-	-	-0.0009	-0.001	-
			(0.48)	(0.57)	
VEHICLE TYPE (1 if car, 0 otherwise)	-	-	-0.0014	-0.001	-
			(0.97)	(1.01)	
RACE OF HEAD OF HOUSEHOLD (1 if white, 0 otherwise)	-	-	0.013***	0.013***	-
			(9.32)	(9.06)	
HIGH SCHOOL GRADUATE (1 if graduated, 0 otherwise)		-	0.001	0.001	-
			(1.05)	(1.03)	
COLLEGE GRADUATE (1 if graduated, 0 otherwise)	-		-0.0009	-0.001	-
			(0.93)	(1.02)	
INCOME OF HOUSEHOLD	-		-0.00001	-0.00004*	-
			(0.63)	(1.53)	
$INCOME^2$	-	-	-	6.72E-09	-
				(0.70)	
AGE OF $HOUSEHOLD^2$	-	-		-0.00003***	-
				(4.54)	
TRADED (age 10 and above)	-	-	-		0.004*
					(1.45)

Z- statistics are in parentheses. *** Denotes significance at 1 percent level; ** Denotes significance at 5 percent level; and * Denotes significance at 10 percent level. Column 1 reports Tobit estimates, columns 2 reports Tobit estimates with additional explanatory variables, and column 3 reports Tobit estimates for traded cars of age 10 years and above.