DEMAND FOR AUTOMOBILE INSURANCE IN THE UNITED STATES

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Abstract

The United States property-liability market is the largest nonlife market in the world, with premiums of $401 billion in 2000 or 44 percent of the world market. There are approximately 2,500 property-liability insurance companies licensed in the United States, with more than half writing personal lines. Private passenger and commercial automobile together account for 47 percent of the total property-liability premiums. This article examines the factors that determine demand for automobile insurance in the United States, including price, income, household characteristics (age), urbanization (traffic density), law and regulation (add-on and no-fault), and number of automobiles registered. The analysis involves cross-section, time series data from all states except Washington D.C. for the period 1982 through 1994. Problems caused by autocorrelation and heteroscedasticity are tested and controlled for. Both fixed and random effects models are estimated. Regression analysis results suggest the fixed effects model with autocorrelation is best suited for the data. The results show that income, traffic density, add-on, and number of automobiles registered are positively related to the demand for automobile insurance whereas age and price have a negative impact.

1. Introduction

The United States property-liability market is the largest nonlife market in the world, with premiums of $401 billion in 2000 or 44 percent of the world market (Sigma, 2000). This is four times the premium volume of the second largest market, Japan. More than half of the property-liability insurance companies licensed in the United States write personal lines, and private passenger and commercial automobile accounts for 47 percent of the total property-liability premiums (Best's Aggregates and Average, 2000).

Considerable research has been published on the determination of the optimal insurance coverage and insurance demand for both life and property-liability insurance, and this research indicates the factors that lead to variation in the demand for life insurance and property insurance are somewhat different. The dependency ratio, national income, government spending on social security, inflation, and price of insurance (Browne and Kim, 1993 and Outreville, 1996) are important factors for life insurance consumption whereas population density, income, price of insurance (Sherden, 1984) and the legal system (Kleffner and Schmit, 1999) are important factors for nonlife insurance. Income, wealth, percent of a country's insurance market controlled by foreign firms, and the form of the legal system in the country are important factors for motor vehicle and general liability insurance consumption at the international level (Browne, Chung and Frees, 2000).

Although demand theory for insurance is well established, there has not been extensive study of the determinants of the demand for automobile insurance in particular. The purpose of this paper is to analyze factors that determine demand for automobile insurance in the United States. The data used in this paper are at the state level and cover the period 1982 to1994, which is more recent than previous research. In addition, use of cross-section, time-series data: (1) allows estimation of effects that could not be detected by cross-section or time-series data only, (2) allows controls for state heterogeneity, and (3) leads to more efficient estimation of the parameters than for cross-section or time-series data alone. Moreover, several previously untested demographic and control variables are added to the model in this research to better understand demand for automobile insurance. These variables include add-on, no-fault, traffic density, age, and number of automobiles registered. In addition, knowing price and income elasticity will help understand price controls associated with regulation and residual markets, and incentives associated with underpricing.

In the next section a literature review is presented. Section III provides a discussion of the methodology used to model demand for automobile insurance and the data set used in this paper. Section IV presents the empirical results and section V concludes.

2. Literature Review

2.1 Demand Theory

Although insurance demand theory is well established, there has not been extensive study with respect to automobile insurance.[1] The expected utility paradigm suggests that demand for insurance depends on risk aversion or the wealth effect on the propensity to buy insurance coverage. An individual is viewed as risk averse if he prefers receiving the mean of any wealth distribution with certainty rather than taking risk for more wealth under uncertainty.

Assume that an individual has an initial wealth of amount A > 0, which is subject to a random loss of amount $\tilde{L}$. Insurance is available, which pays out the indemnity I(L) when the realized loss is L, for the premium P[I(L)]. In particular, consider the fairly common case in which I(L) = αL, where α is chosen by the insured, $0 \leq \alpha \leq 1$, and where the premium for partial coverage is proportional to the full-coverage premium. Thus, the individual's wealth prospect is

$\tilde{w}_a = A - \tilde{L} - \alpha P_f + \alpha \tilde{L} = (A - P_f) + (1-\alpha)(P_f - \tilde{L})$, where P_f denotes the premium for full coverage:

$P_f = (1+\lambda)\, E(\tilde{L}), \quad \lambda \geq 0$. The coefficient λ is the premium loading factor for profit and expenses.

A risk-averse expected-utility maximizer buying proportional insurance coverage will choose full coverage ($\alpha^* = 1$) if $\lambda = 0$ or partial coverage ($\alpha^* < 1$) if $\lambda > 0$ (Mossin, 1968).

If we combine preferences with the conventional linear budget constraint $\Sigma\, p_k q_k = M$ where p_k and q_k the price and quantity of good k and M is the total budget, this will lead to the standard utility maximization problem:

Maximize U(q) = U subject to $\Sigma\, p_k q_k = M$.

Applying the concept of production theory, which is based on the concept of a cost function, to utility and demand theory results in the "dual" problems of cost minimization and output maximization:

Minimize $M = \Sigma\, p_k q_k$ subject to U = U(q).

In order to solve both problems, optimal values of q are needed.

Demand functions can be written as $q_i = g_i(M,p)$. These relationships, which give quantities as a function of prices and total expenditures, are referred to as Marshallian demand functions.

The fact that the demand functions satisfy the budget constraint $M = \Sigma\, p_k q_k$ places a constraint on the function g_i. This constraint which is referred to as the adding-up restriction can be written as $\sum_k p_k g_k(M,p) = M$.

Since the budget constraint is linear and homogeneous in M and p, the vector q will also satisfy the constraints for any multiple of M and p. This restriction, which implies that the demand functions are homogeneous of degree zero is referred to as the homogeneity restriction, and can be written as $g_i(\theta M, \theta p) = g_i(M,p)$, $\theta > 0$, i = 1,…,n.

We can express the adding-up restriction and the homogeneity restriction as restrictions on the derivatives of the demand functions rather than the functions themselves. The adding-up restriction implies that

$$\sum_k p_k (\partial g_k / \partial M) = 1 \quad ; \quad \sum_k p_j (\partial g_j / \partial p_i) = 0$$

and homogeneity implies that

$$\sum_j p_j (\partial g_i / \partial p_j) + M (\partial g_i / \partial M) = 0.$$

If we define the budget shares (the fractions of total expenditures going to each good) w_i as $w_i = p_i q_i / M$ or $\log w_i = \log p_i + \log q_i - \log M$, the total expenditure elasticity e_i as $e_i = \partial \log g_i(M,p) / \partial \log M$ and price elasticity e_{ij} as $e_{ij} = \partial \log g_i(M,p) / \partial \log p_j$, then the adding-up restriction is equivalent to $\sum_j w_j e_j = 1$; $\sum_j w_k e_{ji} + w_i = 0$

and the homogeneity restriction can be written as $\sum_j e_{ij} + e_i = 0$.

$\log w_i = \log p_i + \log q_i - \log M$ can be written under the double logarithmic model

$\log w_i = \alpha_i + (e_i - 1) \log M + (e_{ii} + 1) \log p_i + \sum_{j \neq i} \log p_j$ (Deaton and Muellbauer, 1989).

Therefore demand for automobile insurance can be assessed using a demand curve such as

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[1] Sherden (1984) studies the effect of price, income, and perceived risk on the demand for three major automobile insurance coverages (bodily injury, comprehensive, and collision) in Massachusetts in 1979 and Chambers (1992) examines the aggregate automobile insurance in the United Kingdom from 1950 to 1984.

$$w_i = a_i + \sum_{j=1}^{k} \ln p_j + b_i \ln (M/P),$$

where w_i is the budget share, p_j is the price, M is the total budget, and P is a general price index, subject to minimizing the cost function

$$\ln C(U, p) = a(p) + b(p),$$

where U is the utility.

Another demand function is

$$\ln q_i = \ln a_i + n_i \ln M + \sum_{j=1}^{k} e_{ij} \ln p_j,$$

where e_{ij} is the price elasticity and n is the marginal utility of income (Weiss, 1991).

2.2 Literature Review

Insurance demand theory based on the expected utility paradigm suggests that the purchase of insurance depends on a number of different factors. Showers and Shotick (1994) study the impact of household characteristics on demand for total insurance (health, life, auto and homeowners insurance) using data from 1,723 households from the 1987 Consumer Expenditure Survey (CES) (U.S. Department of Labor, 1987). They find that income and number of earners are both positively related to a household's demand for insurance. However, the marginal effect from an increase in income is greater for single-earner households than for multiearner households. In addition, the marginal increase in insurance expenditure from an increase in income decreases as either family size or age increases.

Browne and Kim (1993) examine factors that lead to variations in the demand for life insurance in 1987 based on a sample of countries spread throughout the world and find that the dependency ratio, national income, government spending on social security, inflation, and the price of insurance are important factors that affect the demand for life insurance. The dependency ratio, national income, social insurance are positively correlated with life insurance demand whereas inflation and the price of insurance are negatively related with life insurance demand. Outreville (1996) also studies life insurance markets in developing countries, using cross-section data for 48 developing countries in 1986 from a statistical survey by UNCTAD (1990), and finds that life insurance is affected by income, the anticipated rate of inflation, life expectancy at birth, the level of financial development, and the presence of a monopolistic market. Demand for life insurance is negatively affected by the anticipated rate of inflation and the presence of a monopolistic market but is positively associated with income, life expectancy at birth, and the level of financial development. Babbel (1985) studies the price sensitivity of consumer demand for whole life insurance based on whole life insurance sold in the U.S. during the period of 1953-1979 and finds that new purchases of whole life insurance are inversely related to changes in a real price index.

Regarding non-life insurance, Browne, Chung, and Frees (2000) study the demand for automobile and general liability insurance consumption across OECD members over the period 1987 to 1993 and find that income, wealth, the percent of a country's insurance market controlled by foreign firms, and the form of the country's legal system are related to demand for both types of insurance. Outreville (1990) also studies property-liability insurance at the international level. Based on cross-section data of 55 developing countries in 1982, he finds that demand for property-liability insurance is related to personal disposable income and the country's level of financial development. The income elasticity is greater than one, and the demand for insurance increases significantly as the level of financial development increases. Sherden (1984) studies the demand for three major automobile insurance coverages (bodily injury, comprehensive, and collision) based on cross-section data of 39 towns and cities in Massachusetts in 1979 and finds that the demand for these three coverages is related to the population density and that it is inelastic with respect to price and income.

3. Data and Methodology

3.1 Data

The data used in this paper are at the state level and cover the period 1982 to 1994. Sources of data and definition of variables are presented in Table 1.

Table 1 Definition of Variables and Source of Data

Variables	Definition	Source
OUTPUT	Present Value of Total Direct Loss Incurred	NAIC Annual Statements
INCOME	Real Income per Capita	U.S. Department of Commerce, *Statistical Abstract of the U.S.*
PRICE	Inverse Loss Ratio	NAIC Annual Statements
TDENSITY	Traffic Density (Vehicle Miles/Miles of roadway)	U.S. Department of Commerce, *Statistical Abstract of the U.S.*
AGE	Percentage of Population Age 18-24	U.S. Department of Commerce, *Statistical Abstract of the U.S.*
ADDON	Dummy Variable = 1 if Add-on	*Summary of Selected State Laws and Regulations Relating to Automobile Insurance*. American Insurance Association
NOFAULT	Dummy Variable = 1 if No-fault	*Summary of Selected State Laws and Regulations Relating to Automobile Insurance*. American Insurance Association
REGISTER	Number of Automobiles Registered in a State	U.S. Department of Transportation, H*ighway Statistics*

Output

Insurers generally provide three principal services; risk-pooling and risk-bearing, intermediation, and real financial services relating to insured losses. Insurers provide a mechanism for individuals and businesses exposed to insurable risks to engage in risk reduction through risk-pooling. They collect premiums from their customers and redistribute most of the funds to those who sustain losses. Policyholders receive a discount in the premiums they pay to compensate for the opportunity cost of the funds held by the insurance companies. The net interest margin between the rate of return earned on assets and the rate credited to policyholders represents the value-added of the intermediation function. Insurers also provide a variety of real services for policyholders. These services include risk surveys, the design of coverage programs, recommendations regarding deductibles and policy limits, and loss prevention services. Since insurance outputs consist primarily of services, many of which are intangible, it is necessary to find suitable proxies for the volume of services provided by insurers (Cummins and Weiss, 1999).

Although many studies use premium income as a proxy for output, it is suggested that this is inappropriate since it leads to simultaneous equation bias and measurement errors in variables (Cummins and Weiss, 1999 and Doherty, 1981). According to Doherty (1981), measures of output using premium income as a proxy are not independent of the pricing policies adopted by firms. Their use in the single equation regression model to estimate the cost function violates the assumption of no correlation between the explanatory variables and the disturbance term (Gujarati, 1995). This violation leads to biased and inconsistent estimators and the use of t-statistics will no longer be applicable. Since the function of insurance is to pool risk among the insureds and provide a guarantee of payments for claims arising from losses covered in the policy, the appropriate output measure should be the expected value of that guarantee (Weiss, 1991 and Doherty, 1981).

However, the use of claims provides only a partial measure. Insurance reduces more risk for an insured whose loss distribution has a high variance than for the insured whose loss distribution has the same expected value but a lower variance. In addition, the greater the value of the risk reduction, the greater the degree of individual risk aversion. These differences would be reflected in the premium paid in a perfect market. But this might not be the case for the property-liability market which is characterized by imperfect information. However, Doherty suggests that the use of claims as a proxy for output outweighs the use of premium in terms of eliminating simultaneous equation bias.

Since the primary purpose of insurance is to redistribute losses among the pooled policyholders, services or output of insurers is assumed to vary directly with expected losses (Cummins and Weiss ,1999). In this research direct losses incurred, not the premiums, are used as a measure for output to avoid simultaneous equation bias and to reflect the fact that the purpose of insurance is to redistribute losses among the policyholders.

Income

Income is hypothesized to positively affect insurance demand. One measure of income is income per capita. Beenstock, Dickinson, and Khajuria (1988) find a positive relationship between income and demand for property/liability insurance in a cross-section analysis of 45 developed and developing countries in 1981. Outreville (1996) also finds a positive relationship between property/liability insurance demand and the GDP per capita in a cross-section analysis of 55 developing countries in 1984. In addition, Browne, Chung, and Frees (2000) find a positive relationship between income (GNP per capita) and demand for automobile insurance in the cross-section, time-series data of OECD member countries during the period 1987 to 1993.

However, Sherden (1984) finds that automobile insurance is perceived as a necessary purchase and is generally insensitive to income. Bodily injury coverage was found to be substantially more income-sensitive than comprehensive and collision coverages and collision coverage was more income-sensitive than comprehensive coverage. This suggests that collision coverage is more of a luxury good than is comprehensive coverage.

Price

Frech and Samprone (1980), Doherty (1981), Outreville (1996), and Weiss (1991) use the inverse loss ratio whereas Cummins and Danzon (1997) use the inverse of the economic loss ratio as a price measure. The inverse loss ratio indicates the cost per dollar of losses required to administer the insurance mechanism. A negative relationship is expected between price and automobile demand.

Outreville (1996) and Weiss (1991) found a negative relationship. Regarding individual price sensitivity, the individual may be willing to take more risk and accept higher deductibles which can reduce insurance coverage.

Sherden (1984) also proposed that if price of coverage increased and absorbed an increasingly greater share of consumers disposable incomes, demand would likely decrease at an increasing rate.

Cummins and Danzon (1997) proposed that demand for insurance is imperfectly price elastic as a result of information asymmetries and private information. They found that price is less responsive to capital shortage and a shift in demand may decrease the negative impact of loss shocks on price for commercial general liability coverage in the 1980s.

In this paper, the inverse loss ratio is used as a proxy for price of automobile insurance.

Urbanization

Urbanization is the proportion of a state's population living in urban areas. The frequency of losses is greater in areas with higher rates of urbanization since a higher rate of interaction exists among individuals. Sherden (1984) referred to this factor as "locational risk" and used population per square mile density as a measure of urbanization. He found that demand increased substantially over low-density to moderately dense areas and only slightly over average-density to highly dense areas. Another potential measure of locational risk is traffic density. Traffic density is defined as the proportion of total vehicle miles to total miles of roadway.

Household characteristics

Showers and Shotick (1994) attribute inelastic income demand to the emergence of multi-earner households. They suggested that the marginal utility from each additional dollar spent on insurance is lower for multi-earner households, ceteris paribus. Consumers in households with many income earners may feel more secure than consumers in a single-earner household and have a higher probability of receiving some type of employer-paid or subsidized life and health insurance.

Another finding is that there is a marginal effect as household size increases. The purchase of insurance increases on average with an increase in household size but this effect decreases as family size becomes bigger. The same result was also found for the increase in age of the head of the household. In this paper, age is used as a proxy for household characteristics.

Law and Regulation

Jaffee and Russell (1998) found a positive relationship between the insurance premium and the number of uninsured drivers. This might imply that insurance premium regulation such as Proposition 103 may enhance consumer welfare since it reduced the proportion of uninsureds.

Suponcic and Tennyson (1998) found that regulation lowers the number of firms in the market, average market share, and output growth of low-cost and national producers in the market. However, they found no significant effects of regulation overall. But stringent rate regulation is negatively and significantly related to annual change in premium volume for national direct writers, national auto specialists, and the Big Four (State Farm, Allstate, Farmers, and Nationwide). Regulation could have adverse effects on consumer welfare. If firms that achieve the largest size or specialize in automobile insurance are the lowest cost providers, the decline in their relative share will increase the price of insurance.

Browne and Puelz (1996) find that Automobile Compensation or No-Fault Laws, which allow automobile accident victims to receive certain benefits regardless of who was at fault, have an impact on automobile liability cost by increasing the claim size. In addition they find that the presence of add-on Laws, which allow automobile victims no limits on lawsuits, increase demand for automobile insurance.

Number of Automobiles registered

Since the demand for automobile insurance is a derived demand, being compulsory given that an individual owns an automobile, we can use this information to identify demand for automobiles by including number of automobiles registered in a given state in the model.

3.2 Methodology

We use a regression model to determine income and price elasticity of demand for automobile insurance. We perform regression analysis to determine which model provides a better fit and has higher explanatory power. Although

OLS estimators are unbiased and consistent, they are not efficient if autocorrelation and heteroscedasticity problems exist. Therefore the Generalized Least Squares (GLS) estimator is recommended since the GLS estimator is unbiased, consistent, and the minimum variance unbiased estimator. Since data used in this study are cross-section, time-series the basic framework for this analysis is a regression model of the form

Y_{it} = á$_i$ + â$^{/}$ x_{it} + å$_{it}$

The individual effect, á$_i$, is taken to be constant over time t and specific to the individual cross-sectional unit i. There are two basic frameworks used to generalize the model. The fixed effects approach takes á$_i$ to be a group specific constant term in the regression model. The random effects approach specifies that á$_i$ is a group specific disturbance, similar to å$_t$ except that for each group, there is but a single draw that enters the regression identically in each period (Green, 2000). The fixed effects for our data are state effects and time effects whereas the random effects are error components.

The functional forms most frequently used to estimate demand might be the linear or log-linear models:

Output $_{it}$ = á $_{it}$ + â$_1$ Tdensity $_{it}$ + â$_2$ Addon $_{it}$ + â$_3$ Nofault $_{it}$ + â$_4$ Income $_{it}$ + â$_5$ Age $_{it}$ + â$_6$ Price $_{it}$ + â$_7$ Register $_{it}$ + å $_{it}$
(1)

Log(Output) $_{it}$ = á $_{it}$ + â$_1$ Log(Tdensity) $_{it}$ + â$_2$ Addon $_{it}$ + â$_3$ Nofault $_{it}$ + â$_4$ Log(Income) $_{it}$ + â$_5$ Log(Age) $_{it}$
+ â$_6$ Log(Price) $_{it}$ + â$_7$ Log(Register) $_{it}$ + å $_{it}$
(2)

We use a statistical program in LIMDEP to analyze our data and correct for autocorrelation and heteroscedasticity problems. Descriptive statistics for variables used in both models are presented in Table 2. (See Appendix 1 for Correlation Matrices for variables in both models).

Table 2 Descriptive Statistics

Variable	Mean	Standard Deviation
OUTPUT	620037639.	824090079.
TDENSITY	.568143015	.416632224
ADDON	.207692308	.405967691
NOFAULT	.290769231	.454466984
INCOME	6.42018959	1.13079438
AGE	.111957343	.012325959
PRICE	1.29272955	.146218825
REGISTER	2704912.80	2888569.85
LOUTPUT	19.6036135	1.16806515
LTDEN	-.835637227	.769473329
LINCOME	1.84427109	.174032503
LAGE	-2.19567184	.109973818
LPRICE	.250339209	.113771009
LREG	14.3399912	1.01911526

4. Empirical Results

Equations 1 and 2 are estimated under varying assumptions regarding the error models to determine the model with the best fit and highest explanatory power. The best results are found with the log-linear model. Variables in the log-linear model have higher t-values, lower standard deviations, and lower p-values. (See Appendix 2 for complete regression results).

The results of the regression analysis for the log-linear model are presented in Table 3.

Table 3 Results for Regression Analysis

Variable	Coefficient and Standard Error								
Time	No Effects	State Effects					Time Effects	State and Effects	
Random Effects		Fixed Effects	White (1)	White (2)	Fixed Effects w/ Autocorrelation	Random Effects		Fixed Effects	
CONSTANT	9.3214 (1.088)					10.6129 (1.077)		5.3383 (9.689)	10.5811 (.9954)
LTDEN	.0880 (.0744)	.8223 (.0596)	(.0684)	(.0608)	.8439 (.0614)	.7858 (.0596)	-.0016 (.0796)	-.0624 (.6405)	.7676 (.0580)
ADDON	-.1672 (.1087)	.1634 (.0523)	(.0472)	(.0495)	.1622 (.0542)	.1555 (.0534)	-.1769 (.1079)	-.4089 (.4391)	.1576 (.0516)
NOFAULT	.1496 (.1015)	.02998 (.0927)	(.0603)	(.1004)	.04019 (.0946)	.0276 (.0916)	.1779 (.1014)	-.8862 (.7771)	.01837 (.0898)
LINCOME	-1.1523 (.3135)	.4614 (.0866)	(.0856)	(.0885)	.4517 (.0892)	.4617 (.0886)	-1.234 (.3380)	-.6530 (1.233)	.4708 (.0860)
LAGE	-3.3045 (.4151)	-2.146 (.0884)	(.1079)	(.0912)	-2.123 (.0919)	-2.2049 (.0895)	-.1437 (.7437)	-.1772 (1.363)	-2.2179 (.0862)
LPRICE	-.8858 (.3689)	-.7084 (.0573)	(.0631)	(.0577)	-.6938 (.0582)	-.6883 (.0581)	-.5718 (.4381)	.4650 (.5783)	-.7026 (.0572)
LREG	.3792 (.0487)	.3178 (.0769)	(.0778)	(.0752)	.3308 (.0852)	.2849 (.0755)	.4276 (.0493)	1.0638 (.6566)	.2834 (.0697)
R-Squared Adjusted R^2	.22023 .21173	.98755 .98637			.98930 .98820	.21914	.25517 .23270	.14850 .04715	.22023
S^2	1.0755	.01859			.01634	s_e^2 =.0179 s_u^2 =2.003	1.0469	1.2978	s_e^2 =.0187 s_u^2 =1.787
F-statistic	25.90	832.60					8.749	1.5778	

Table 3 presents the demand equations with individual state effects, specific period effects, and both state and period effects. The F statistic for testing the joint significance of the state effects is F [49,593] = 832.596. The critical value from the F table is 1.376. Therefore there is a significant demand difference across the different states. In addition, all coefficients (except for NOFAULT) are statistically significant. The regression model predicts movements in the dependent variable very well, with an R^2 of 0.988.

The F statistic for testing the joint significance of the period effects is F [12,630] = 8.749. The critical value from the F table is 1.768. Therefore there is a significant demand difference across the different periods. However, only the LINCOME and LREG's coefficients are statistically significant, and the R^2 (0.256) is lower.

The F statistic for testing the joint significance of the state and period effects is F [62,587] = 1.578. The critical value from the F table is 1.336. However, none of the coefficients are statistically significant. The low R^2 (0.148) indicates a lack of fit of this model. Overall, the conclusion is in favor of a significant demand difference across the different state and periods.

To test for random effects, we obtain a Lagrange multiplier test statistic of 326.673, which far exceeds the 95 percent critical value for a chi-squared statistic with one degree of freedom, 3.84. Therefore, we conclude that the regression model with a single constant term is inappropriate for these data. The result of the test is to reject the null hypothesis in favor of the random effects model. However, this might be a result of the fixed effects as well.

The Hausman test for the fixed and random effects regressions is based on the parts of the coefficient vectors and the asymptotic covariance matrices that correspond to the slope in the models (that is, ignoring the constant terms (Green, 2000)). The Hausman statistic is 22.609. The critical value from the chi-squared table with seven degrees of freedom is 14.067. Therefore we reject the hypothesis that the individual effects are uncorrelated with the other regressors in the model and conclude that the fixed effects model is the better choice.

Table 4 Fixed Effects Models (State), with Autocorrelation

Variable	Coefficient and Standard Deviation	t-statistic
LTDEN	0.8439 (0.0614)	13.752***
ADDON	0.1622 (0.0542)	2.994***
NOFAULT	0.0402 (0.0946)	0.425
LINCOME	0.4517 (0.0892)	5.064***
LAGE	-2.1232 (0.0919)	-23.083***
LPRICE	-0.6938 (0.0582)	-11.932***
LREG	0.3308 (0.0852)	3.885***
R-squared	.989300	
Adjusted R-squared	.98820	
Estimated Autocorrelation of e(i,t)	-.061195	

*** significant at .01

We choose the fixed effects model with autocorrelation over the fixed effects model with heteroscedasticity corrected asymptotic covariance matrix[2]. All variables except NOFAULT in both models are significant but the fixed effects model with autocorrelation has higher explanatory power (higher R-squared; .98930 > .98755 and higher adjusted R-squared; .98820 > .98637).

[2] White (1) is the fixed effects model with heteroscedasticity corrected asymptotic covariance matrix with the end result scaled up by a factor n/(n-K) and White (2) is the fixed effects model with heteroscedasticity corrected asymptotic covariance matrix with the squared residual scaled up by its true variance.

The LTDEN variable is positive and significant. This supports the hypothesis that demand for automobile insurance increases with higher rates of urbanization since a higher rate of interaction exists among individuals. This result is consistent with the findings of Sherden (1984). Sherden found that demand increased substantially over low-density to moderately dense areas and only slightly over average-density to highly dense areas.

The ADDON variable is positive and significant. This reinforces the findings of Browne and Puelz (1996) that the presence of add-on is associated with increased demand for automobile insurance. Although the NOFAULT variable is not significant, its positive coefficient is consistent with the findings of Cummins and Weiss (1999).

The LINCOME variable is also positive and significant. This is consistent with the previous findings of Beenstock, Dickinson, and Khajuria (1988), Outreville (1996), and Browne, Chung, and Frees (2000). As income increases, demand for automobile insurance increases as well.

Since we face the problem of collinearity in our data, the age variable is the only household characteristic used in the equation. The LAGE variable is negative and significant. This means that the higher the percentage of the population aged between 18 and 24, the lower is the demand for insurance. This is consistent with the findings by Showers and Shotick (1994) that the marginal change in insurance expenditure was substantially smaller for younger households.

The LPRICE variable is negative and significant. Since we use the inverse loss ratio which indicates the cost per dollar of losses required to administer the insurance mechanism as a proxy for price, a negative relationship is expected between price and automobile insurance demand. This negative relationship is consistent with the findings of Outreville (1996) and Weiss (1991). Regarding individual price sensitivity, the individual may be willing to take more risk and accept higher deductibles which can reduce insurance coverage.

The LREG variable is positive and significant. Since demand for automobile insurance is a derived demand, demand is expected to increase as the number of automobiles registered increases.

5. Conclusions

In this paper, we estimate a log-linear model for automobile insurance demand that includes traffic density, add-on, no-fault, real income, age, price and number of automobiles registered as independent variables. Data from all states except Washington D.C. for the period 1982 to 1994 are used. The empirical model tests and controls for autocorrelation and heteroscedasticity. Both fixed and random effects models are estimated. The results support the fixed effects model with autocorrelation. In the model, all variables except no-fault are significant. Traffic density, add-on, income, and number of automobiles registered are positively related to demand for automobile insurance whereas age and price are negatively related to demand for automobile insurance.

Although the regression results reinforce the previous research findings, we exclude some intended demographic variables that might impact demand for automobile insurance (hospital costs per day, percentage of population age 25 and over with a Bachelor’s degree, and habit formation) because of collinearity among these variables. In addition, the data used in this paper are at the state level. Future research might try to obtain data at the firm (insurer) level to examine automobile demand in each state.

However, data used in this paper are more up-to-date than previous research. In addition, our cross-section, time-series data are better able to identify and estimate effects that cannot be detected by using only cross-section or time-series data (as used in previous research). Panel data also allow control for individual heterogeneity and allow for more efficient estimation of the parameters. Moreover, several previously untested demographic variables (add-on, no-fault, traffic density, age, and number of automobiles registered) are added to the model to better understand demand for automobile insurance.

The results are very important. Examining factors underlying insurance consumption is important for policy makers in both public and private sectors. It will provide valuable insights for both insurers and regulators so that they can better understand the limitations or opportunities involved in fulfilling the risk-aversion needs of the population and play a significant role in anticipating future insurance demand and alternatives to insurance.

Appendix 1
Correlation Matrix for Listed Variables

Linear Model

	OUTPUT	ADDON	NOFAULT	TDENSITY	INCOME	AGE	PRICE	REGISTER
OUTPUT	1.00000	-.03581	.06241	.19686	.09577	-.22342	.01673	.63421
ADDON	-.03581	1.00000	-.32783	.04378	.06279	-.00372	-.09466	-.02424
NOFAULT	.06241	-.32783	1.00000	.29721	.26565	-.00706	-.05940	.13584
TDENSITY	.19686	.04378	.29721	1.00000	.61584	-.07904	-.08289	.44132
INCOME	.09577	.06279	.26565	.61584	1.00000	-.33569	-.10007	.28768
AGE	-.22342	-.00372	-.00706	-.07904	-.33569	1.00000	-.11083	-.10212
PRICE	.01673	-.09466	-.05940	-.08289	-.10007	-.11083	1.00000	-.00134
REGISTER	.63421	-.02424	.13584	.44132	.28768	-.10212	-.00134	1.00000

Log-linear Model

	LOUTPUT	ADDON	NOFAULT	LTDEN	LINCOME	LAGE	LPRICE	LREG
LOUTPUT	1.00000	-.07187	.12808	.17251	.01367	-.23387	.01913	.37149
ADDON	-.07187	1.00000	-.33116	.06410	.06402	.00042	-.10322	.00581
NOFAULT	.12808	-.33116	1.00000	.19758	.27287	-.01885	-.05219	.21519
LTDEN	.17251	.06410	.19758	1.00000	.55070	-.01168	-.10502	.54227
LINCOME	.01367	.06402	.27287	.55070	1.00000	-.26906	-.03903	.24644
LAGE	-.23387	.00042	-.01885	-.01168	-.26906	1.00000	-.25300	-.08988
LPRICE	.01913	-.10322	-.05219	-.10502	-.03903	-.25300	1.00000	-.01745
LREG	.37149	.00581	.21519	.54227	.24644	-.08988	-.01745	1.00000

Appendix 2
Comparison of the Linear and Log-linear models

Variable	Coefficient	Standard Error	b/St.Er.	P[|Z|>z]	Mean of X
Linear Model					
Constant	2637920738.	.43368630E+09	6.083	.0000	
TDENSITY	-42309067.13	80940702.	-.523	.6012	.56814301
ADDON	-13117419.65	64342310.	-.204	.8385	.20769231
NOFAULT	28888441.08	60269106.	.479	.6317	.29076923
INCOME	-116896739.1	29585504.	-3.951	.0001	6.4201896
AGE	-.1427416454E+11	.21405125E+10	-6.669	.0000	.11195734
PRICE	-132609305.3	.16859985E+09	-.787	.4316	1.2927296
REGISTER	189.9016102	9.3373744	20.338	.0000	2740912.8
Log-linear Model					
Constant	9.321484191	1.0877275	8.570	.0000	
LTDEN	.8797596730E-01	.74421203E-01	1.182	.2372	-.83563723
ADDON	-.1672248452	.10869966	-1.538	.1239	.20769231
NOFAULT	.1496118456	.10145621	1.475	.1403	.29076923
LINCOME	-1.152267537	.31353520	-3.675	.0002	1.8442711
LAGE	-3.304477629	.41505562	-7.962	.0000	-2.1956718
LPRICE	-.8858218193	.36893714	-2.401	.0163	.25033921
LREG	.3792314215	.48652414E-01	7.795	.0000	14.339991

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