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THE DEMAND FOR NEW CARS AND THE INDEX OF CONSUMER SENTIMENT

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Abstrak

Indeks Sentimen Konsumen (ISK) banyak digunakan sebagai pengukur keyakinan pembelian di masa mendatang untuk memprediksi perilaku pembelian agregat di masa datang. Studi ini secara empiris membandingkan antara dua model proyeksi : model pengharapan *(the expectation model)* yang memasukkan ISK sebagai variabel penjelasan dan model tradisional (*the traditional model)* yang tidak memasukkan ISK. Kedua modal tersebut digunakan untuk mengestimasi permintaan agregat atas mobil baru di Amerika sejak 1976 sampai 1984. Hasil studi mengindikasikan bahwa ISK memiliki hubungan positif dengan penjualan mobil baru. Namun, berdasarkan kemungkinan kriteria dominan *(the likelihood dominance criterion)*, model tradisional lebih baik dibandingkan model pengharapan. Selain itu, kemampuan memprediksi dari model pengharapan sedikit lebih rendah dibandingkan model tradisional.

Abstract

The index of consumer sentiment (ICS) has been widely employed as a proxy for future buying confidence to predict future aggregate buying behavior. This study empirically compares two forecast models: the expectation model that includes the ICS as an explanatory variable and the traditional model that does not include the ICS. The models are employed to estimate the aggregate demand for new cars in the U.S. from 1976 to 1984. The results indicate that the ICS has a positive relation with new car sales. On the basis of the likelihood dominance criterion, however, the traditional model is preferred to the expectation model. Furthermore, the forecast ability of the expectation model is slightly inferior to the traditional model

Keywords : *Index of Consumer Sentiment (ICS), Demand for New Cars, Forecast Model*

1. Introduction

The index of consumer sentiment (ICS) has been widely employed as a proxy for future buying confidence to predict future aggregate buying behavior. The ICS is especially important determinant for predicting the demand for consumer durable, such as cars, because consumer durable are characterized by extensive decision-making effort (Howard and Sheth, 1969) and therefore typically involve long-term decision planning. For these products, the ICS can be used in order to anticipate major shifts in consumer intentions and buying plans, and thus the demand for these products.

The ICS has mixed performance in estimating aggregate buying behavior. A study by Burch and Gordon (1984) indicated that the ICS might yield little additional explanatory power to the prediction of future buying behavior, because many of economic variables in their study appeared to account for the majority of variance in buying patterns. Another study (Throop, 1991) however, found the opposite result. As an extension of previous car demand studies, the purpose of this study is to compare a model that includes the ICS as an explanatory variable (i.e., the expectation model) and a traditional model that does not include the ICS by empirically estimating the aggregate demand for new cars in the U.S. from 1976 to 1984. The models are estimated with ordinary least squares (OLS) and feasible general least squares (FGLS) that correct for autocorrelated disturbances. They will be evaluated based on the likelihood dominance criterion (LDC) as suggested by Pollak and Wales (1991) and their forecast ability.

The results show that ICS has a positive relation with new car sales. On the basis of the LDC, however, the traditional model is preferred to the expectation model. Furthermore, the forecast ability of the expectation model is slightly inferior to the traditional model. Lastly, the study finds that there has been a structural change for the car demand in 1979.

The paper is organized as follows. Section II provides a literature overview of the study of the demand for durable consumer goods in general, and the demand for cars in particular. It also describes the ICS and its relation to demand for durable goods. Section III provides the model specification, together with data source and collection. In section IV, the regression results, together with diagnostic tests and forecast results are presented. Section V contains conclusion.

2. Methods

2.1. The Study of Demand for Durable Goods and Cars

The most commonly applied models that explain consumer purchases of durable goods are based on a simple dynamic stock adjustment model that was first developed by Stone and Rowe (1957). The model can be defined as:

$$D_t = a(S_t^* - S_{t-1}) + pS_{t-1} \qquad (1)$$

Where:

D_t = aggregate demand for the durable in period t.

S_t^* = desired stock at the end of period t.

S_{t-1} = Stock of the durable in households' hand at the end of period t-1.

a = adjustment stock coefficient.

P = depreciation rate.

The first term of the equation indicates the additional amount of stock of the durable that is desired in period t and the second term takes account of any replacement demand that occurs in each time period.

The desired stock is defined as a function of some traditional variables, such as income, price, credit conditions, etc. A number of studies have tried to incorporate a variety of variables in the desired stock equation. Among the most relevant variables are measures for the availability and the cost of consumer credit (Hamburger, 1967; Briscoe, 1977) and the operating costs of the durable (Tishler, 1982). Both variables can be regarded as the costs of complementary products for durable and therefore, are expected to have inverse relation with the demand for durable goods. Others try to improve the short-term adjustment mechanism by defining a variable that is expected to shape short-term demand shifts, such as the rate of unemployment (Westin, 1975).

In many studies, replacement demand is simply defined as a percentage of existing stock. Rhys (1972) noted that the approach does lead to acceptable approximations of replacement demand in stable conditions. This approach requires a very restrictive assumption that depreciation rate is a fixed percentage of total stock of cars. De Pelsmacker (1990) commented that as a result of the durability of a car, its replacement can be postponed or speeded up; therefore, replacement demand is not a fixed percentage of existing stock. It could be very flexible and dependent on some factors reflecting the economic situation.

Katona's study (1974) was the first one to incorporate the behavioral-oriented expectation elements in the empirical analysis of both an aggregate and disaggregate consumption spending. Consumer purchases are made by individuals who are not only able but also willing to purchase. Willingness to purchase is the result of consumer attitudes and expectations concerning the present and future state of the economy. If a consumer is more optimistic about the future state of the economy, then he is more likely to purchase durable goods, which require substantial expenditures and involve long-term decision planning. The opposite holds if the consumer is more pessimistic. Given consumers' expectation of the future economy, consumer expectation measures yield not only information about future purchase but also information about the future course of economic activity.

One of the consumer expectation indexes that has been widely shown to predict future purchases is the ICS. The ICS is seasonally adjusted and is published each month by the Survey Research Center at the University of Michigan. The ICS contains information of consumers' perception of present and future states of economy. It solicits the consumers' opinion as to whether they are better off now than they were a year ago. It is a measure of medium to long-run expectation because its survey questions request judgments concerning future economic conditions in the next year and five years. The ICS also provides an indicator of current purchase intention of consumers. Its survey question asks if it is currently is a good time to buy. Therefore, the ICS emphasizes on purchase intentions in the current period.

The ICS have mixed performance in the prediction of future aggregate buying behavior. Some studies (Hymans (1970), Burch and Gordon 1984)) found that the ICS had little predictive value in explaining consumer durable purchases while other studies (Juster and Watchel (1972), Throop (1991), and Huth et. al. (1994)) have shown that the ICS is useful as a predictor of future buyer behavior. Briscoe noted (1977) that the ICS is frequently found to be highly collinear with some traditional economic variables. Further, Smith (1975) showed that consumers' attitudes and intentions are not necessarily independent of the transitory economic variables, especially the level of unemployment. This is consistent with Huth et. al. (1994) findings that the ICS have strong relationships with unemployment rate and interest cost, the two traditional measures that have been widely used in the study of demand for cars. Lastly, Juster and Wachtel (1974) found that the ICS could not account for the impact of relative prices.

The strong relationship between the ICS and some economic variables should be expected. As mentioned earlier, the ICS is a measure of consumers' perception of current and future economic activities. Consumers incorporate all relevant economic variables, which include interest cost and unemployment rate, when making their expectations; therefore the index should be correlated with the economic variables.

2.2. Research Method

Other than measuring purchase intention, the ICS also measures expectation of current and future economic conditions. It does not directly account for the impact of price and income on the demand for durable goods, although price and income are somewhat influenced by economic conditions. If the ICS could replace traditional economic variables such as interest rate and unemployment rate to estimate demand for new cars, the stock adjustment model in equation 1 becomes the following (model 1):

$$D_t = f(P_t, PCY_t, ICS_t, S_{t-1}) \qquad (2)$$

Where P_t is the price of cars, PCY_t is the per capita income, and ICS_t is the index of consumer sentiment[1].

Price (per capita income) is expected to have a negative (positive) relation with the number of cars sold. The ICS is expected to have a positive relation with car sales because as consumers become more optimistic about future economic condition (i.e., the ICS goes up), they will purchase more cars. The ICS is measured without time lag because, as mentioned earlier, the ICS concerns with the impact of consumers' expectation on current purchase. For simplicity reason, I include the lag of stock of cars as a proxy for car replacement. As the number of cars to be replaced increases, the demand for new cars also increases. Thus, there is a positive relationship between the stock variable and demand for cars.

Model 2 is based on the traditional economic model and is defined as follows:

$$D_t = f(P_t, PCY_t, r_{t-1}, U_{t-1}, S_{t-1}) \qquad (3)$$

where r_{t-1} is interest rate and U_{t-1} is unemployment rate both with one lag structure. This allows for the lag in the relationship between the absorption of information about the cost of credit and the economic condition and its translation into the act of purchasing or not purchasing. Since more than 70% of new car purchase involve long-term financing, higher interest rate results in higher cost to purchase cars and therefore should result in lower demand for new cars. Unemployment rate is a proxy for transitory variable and is expected to have negative relationship with demand for cars.

The data are quarterly observations of the variables for the period 1976-1985. The first thirty-six observations are used to estimate the models while the last four observations are used as holdout sample for later forecast. The dependent variable, demand for new cars, is estimated by total new car sales (domestic and import) in the United States. The data is taken from various editions of Wards Automotive YearBook. To control the effect of population growth on car sales, total new car sales are scaled by the population of the U.S. The price of car is based on the three-month average of new car price index developed by U.S. Department of Labor Indexes, and is taken from various editions of Survey of Current Business. Per capita income is defined as the real disposable income per capita and the interest rate is estimated by the three-month average of prime interest rate offered by commercial banks. The data of per capita income, prime rate and unemployment rate are taken from various editions of Economic Report of the President. The quarterly index of consumer sentiment is taken from various editions of Business Condition Digest published by U.S. Department of Commerce.

[1] I exclude the operating cost of cars (that are estimated by the price index of fuel oil) from model 1 and model 2 because the correlation coefficient of the operating cost and price is extremely high (0.96).

The stock variable is measured by total car registration and is taken from the 1988 edition of Motor Vehicle Facts and Figures. Total car registrations are also scaled by the population of the U.S. There is no quarterly data for total car registration, so I assume that the total car registration per capita to be the same in a year. **SHAZAM** – Econometrics Computer Program is used to run all statistics tests and computations.

Since I use quarterly data, seasonality may affect new car sales. To control for seasonality, I include three dummy variables for quarter 1, 2 and 3 in both models.

Previous studies have used both linear and exponential models to estimate the demand for cars. Since a priori there is no justification to prefer one over the other, I estimate the models using OLS estimation for both linear and exponential models. To linearize the exponential model, I take a natural log for both the dependent and regressor variables (except for the dummy variables). Then, based on the LDC, I will select the model that generates the highest log likelihood value. The LDC is also used to compare model 1 and model 2.

The LDC is applicable in cases where there is a need to choose between nonnested models. The principle of the LDC is to select a model that maximizes log likelihood value. If the nonnested models contain the same number of parameters, the criterion is to select the one with the higher log likelihood. If the nonnested models contain different number of parameters, the log likelihood's of the models are not directly comparable and they have to be compared to some critical levels that are proposed by Pollak and Wales (1991).

3. Empirical Results & Discussion

3.1. Linear vs. Exponential Models

For model 1, the log likelihood's for the linear and the exponential models are –28.73 and –27.52 while for model 2, they are –26.33 and –25.13 respectively. Since the linear and the exponential models contain the same number of parameters, the criterion is to select the one with higher log likelihood. The exponential model has higher log likelihood than the linear model for both model 1 and model 2. Based on this, the exponential model is selected to estimate the demand for cars.

3.2. The Expectation Model vs. The Traditional Model

The results of the OLS regressions for model 1 and 2 are shown in Table 1. In both models, the dummy coefficients for quarter 2 are significantly greater than zero ($p<0.001$). The dummy coefficient for quarter 1 is significant at 5% of less only in model 2. This indicates that new car sales in quarter 1 and 2 are significantly higher than quarter 4. Thus, seasonal factor plays an important factor in estimating new car sales. For model 1, except for the stock variable, all coefficients are significant and are in the expected direction. The insignificance of the stock variable may be due to its noisy measure of replacement demand for cars. The use of stock variable requires a stable condition, but during the period of the study, the demand for cars was marked by a structural change and surrounded by unstable economic conditions. This issue is addressed in later sub-section.

For model 2, the coefficients for the prime rate and the unemployment rate are not significantly different from zero. To investigate whether model 2 can be simplified, I ran two regressions where each regression consists of either the prime rate (Model 2a) or the unemployment rate (Model 2b). The results are reported in Table 2. As expected, the coefficient for the prime rate now is significantly negative. Relative to the composite model, other coefficients in model 2a continue to have the same significant signs. In model 2b, the coefficient for the unemployment rate is significant but it is in the opposite direction. The likelihood value for the composite model (57.51) is slightly higher than either the model with the prime rate (57.04) or the model with the unemployment rate (56.05); however, the LDC indicates that the model with the prime rate is preferred to the composite model. It is also preferred to the model with the unemployment rate. Therefore, I drop the unemployment rate variable from model 2 and use model 2a as the basis comparison with model 1.

The log likelihood value for model 1 (55.13) is less than that for model 2a (57.04). Thus, even though on its own the index of consumer sentiment has significant positive relationship with new car sales, the LDC indicates that the expectation model is inferior to the traditional economic model in explaining the variation in new car sales. I also run a regression that combines model 1 and model 2a. The results (not shown) indicate that the ICS is not significantly different from zero while prime rate is still significantly negative at 5% critical level. The log likelihood value of this model is 57.52, and based on the LDC, the model with prime rate (model 2a) is superior to the combined model. This finding is consistent with Burch and Gordon's study (1984) that found that ICS added insignificant explained variance over and above the variance explained by the traditional economic variables.

3.3. Diagnostic checking

a. Autocorrelation[2]

The Lagrange multiplier (LM) test and the Box-Pierce-Jung (BPJ) test are run to test for autorrelation. The Lagrange Multiplier statistic gives a test for HO: $\rho j=0$

while Box-Pierce-Ljung statistic gives a test for H0: $\rho1=\rho2=\ldots=\rho j=0$ where j is for the order of auto correlation. The tests are run for up to ten lags.

For model 1, LM statistics indicate that there are significant autocorrelations at lag 2, 3 and 5; however, the BPJ statistics show that there is no autocorrelation in the first four lags. At lag 5, the BPJ statistic indicates at least one of the lags have autocorrelation greater than zero. For lags greater than five, none of LM and BPJ statistics indicates the presence of autocorrelation. The results of autocorrelation tests for model 2a are similar to those for model 1. The construction of the data may imply such a pattern of strong negative autocorrelation at lag 5. The observations are based on quarterly data and autocorrelation at lag 5 implies that car sales in one quarter depend on car sales in the same quarter one year earlier. I conclude that model 1 and model 2a needs to be corrected for autocorrelation of order 5.

Model 1 and model 2a are reestimated with the correction of autocorrelation of order 5. The residuals are assumed to follow an autoregressive process of order 5 (AR(5)). The correction and the estimation procedures are based on feasible general least squares (FGLS)[3]. The regression results for model 1 and model 2a are presented in Table 3. For

BPG : $\sigma^2_t = \sigma^2(\alpha0+ \alpha'zt)$

Harvey : $\sigma^2_t = \sigma^2\exp(\alpha0+ \alpha'zt)$

Glejser : $\sigma^2_t = \sigma^2(\alpha0+ \alpha'zt)^2$

ARCH : $\sigma^2_t = \alpha0+ \alpha'\, \sigma^2_{t-1}$

Where z is a vector of regressor variables.

All tests for model 1 and model 2a fail to reject the hypothesis that the residual variance is homoscedastic. It appears that heteroscedasticity is not a problem in this series. Both models, except for the dummy coefficient in the third quarter, the standard errors and the t-ratios of the coefficients substantially improve.

The adjusted R-square of both models also increase. A FGLS estimation is more efficient than an OLS estimation if the matrix of the difference between the covariance matrix of OLS and FGLS estimations is positive definite.

The matrix is a positive definite if all its eigenvalues are greater than zero. For model 1 and 2a, not all eigenvalues of the matrix is greater than zero, implying that no conclusion can be made regarding the efficiency of the FGLS model relative to the OLS model. Thus, even though most t-ratios of both models improve, the FGLS estimation is not more efficient than the OLS estimation[4].

b. Test for structural change

The period covered in this study is from 1976 to 1985. During this period, the American economy has gone through a business cycle, starting from a recovery from 1973-75 recession to another recession that started in early 1980 and ended in early 1983.

Beginning in 1979, the price of oil has more then doubled before it leveled off in 1983.There was also a change in the class structure of car sales.

The share of subcompact, compact, and import cars of the total new car sales has substantially increased since 1976. In 1976 the share of subcompact, compact and import cars was 48.8%, while in 1980 it jumped to 63.1%. It has decreased slightly since then. All of these changes may affect the relationship between the regressor variables and new car sales.

To investigate whether there was a structural change in the demand for cars during 1976-84, I perform the Chow test, which gives a test for structural change. Since the exact period where the structural change occurred is unknown, a set of sequential chow test statistics is generated. Each set splits the sample of dependent and regressor variables in 2 pieces at every possible point. The structural change occurs in period where the Chow statistic is greater than the critical level. At 5% critical level, for model 1there were three periods those results in significant Chow test.

[2]Time series data usually meets the constant variance assumption of OLS; however, in some cases the assumption may be violated and this would poses potentially severe problem for inferences based on least squares. Four series of tests are run to test for heteroscedasticity. They are Breusch-Pagan-Godfrey (BPG) test, Harvey test, Glejser test and ARCH test. The tests are different in their assumption of the error structure (Greene, 1993):

[3]Greene (1993) provides a detail explanation of FGLS that corrects for autocorrelation

[4] Both LM and BPJ tests do not indicate whether the residuals follow an autoregressive (AR) process or a moving average (MA) process. To determine which corrected error specification results in efficiency gain in model 1 and 2a, I run FGLS on models with AR(5) and MA(5) corrections. The efficiency tests do not indicate that models with AR(5) are better than those with MA(5). Generally, however, the t-ratios of AR(5) models are higher than those of MA(5). Further, the adjusted R-squares of AR(5) models generally are higher than the adjusted R-squares of MA(5) models. Therefore, I select AR(5) as the structure of the residuals.

The periods were the first quarter of 1979 to the third quarter of 1979. For model 2a, the period that was significant was the third quarter of 1979. The results of Chow test are consistent with the expectation. In 1979, the price of oil jumped, the recession began, and smaller cars became more common in the U.S.

To investigate how the parameter estimates differ before and after the structural change, I divide the sample into two sub-samples at the split point and perform a separate OLS and FGLS on the sub-samples for both models. I select the third quarter of 1979 as the split point for both models because a. the Chow test is significant in both models and b. the sample size of the first sub-sample may become too small if the split period is either in the first or second quarter of 1979.

Because the results for OLS and FGLS are similar, Table 4 only reports the regression results for FGLS models. For the first sub-period, the regression results are very different from those for the combined sample. The coefficient for price becomes significantly positive while the coefficient for disposable income is significantly negative in model 2a and is not significant in model 1. The stock variable becomes significantly positive in model 2a while it stays insignificant in model 1. The prime rate is negative only at 10% critical level while the ICS stays significantly greater than zero. The regression results are very surprising; however, the coefficients must be interpreted with caution because the degree of freedom of the first sub-period is very low. For the second sub-period, the regression results are similar to those for the combined sample. One noted difference is that the t-ratios generally are higher than the t-ratios in the combined sample. In addition, the stock variable becomes significantly negative in model 1. In summary, the regression results show that the coefficients for price, per capita income, and stock variables change substantially before and after the third quarter of 1979; however, due to small sample, the results must be cautiously interpreted.

3.4. Forecast

I use the holdout sample to compare the forecast accuracy of model 1 and model 2a. Three measures are used for assessing the predictive accuracy of the models: Root means squared error (RMSE), mean absolute error (MAE), and Theil U statistics. Large values of measures indicate a poor-forecasting performance.

Table 5 reports the actual and predicted values of the dependent variable, the 95% forecast intervals, RMSE, MAE, and Theil U statistics for model 1 and 2a. The dependent variable is transformed back to its original values by taking exponential and the calculations are based on the original values. Except for the third quarter of 1985, the actual values of new car sales per capita are within the forecast intervals of all models. For the third quarter, only the forecast interval of the OLS-model 2a includes the actual value. The actual value is slightly above the upper interval of other models. Examination of the data reveals that car sales in that period were highly above their usual pattern. Compared to car sales in the same quarter of previous year, the car sales jumped more than 20%. At the same time, the consumer sentiment index decreased, the new car price index increased, and the per capita income remained stable. The decrease in the prime rate was the only change that was consistent with the jump in car sales. It also explained the more accurate forecast or model 2a in that quarter.

On the basis of RMSE, the traditional model outperforms the expectation model in its forecast ability. The OLS and FGLS estimated traditional models give lower RMSE than RMSE of the OLS and FGLS estimated expectation model. The results for Theil U statistics are consistent with RMSE. These forecast results are consistent with the LDC test. The MAE measure gives a different result. The OLS estimated expectation model gives the lowest MAE while the FGLS estimated traditional model gives the highest MAE. The traditional and expectation models, however, are estimated to minimize the least squares of the residuals and not to minimize the absolute amount of residuals. Thus the MAE results may not be consistent with the RMSE results.

4. Conclusion

The study examines whether a car demand model that is based on the ICS (i.e., the expectation model) is preferred to a traditional model that includes the prime rate. As expected, the ICS is positively related to new car sales, however, based on the LDC, the traditional model is preferred to the expectation model. The ICS does not provide additional explanatory power beyond what already explained by the prime rate and other regressor variables. In addition, on the basis of RMSE, the forecast ability of the expectation model is inferior to the traditional model. These results are consistent with the finding of Burch and Gordon (1984). Lastly, the study found that there has been a structural change for the car demand in 1979.

Like all other studies, this one has its limitations and weaknesses, several of which deserve mention. First, the study uses aggregate data and therefore ignores the fact that automobiles are differentiated products. The ideal approach would be to use disaggregate data and estimate the demand system for a set of differentiated products. In the case of automobiles, though, these techniques are inapplicable. There are over one hundred models available and few models are available for more than four consecutive years. Levinsohn in Baldwin (1988) offers an interesting approach to overcome this problem. Second, the study employs time-series technique to estimate the car demand. This technique has a restrictive assumption that products and tastes or any other structural change remain constant over the period of estimation. Chow test or any other method can be used to detect these changes; however, if the changes occur gradually the detection would be difficult and unreliable. Lastly, the study employs regression models to predict demand for cars. Huth et al. (1994) commented that the methodology is not well suited to the dynamic movement of consumer buying confidence or sentiment and consumer purchase variables over time. He suggested to use vector autoregression time-series techniques to determine whether one variable leads, lags, or moves contemporaneously with another variable.

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Lampiran: TABLE 1
OLS estimation results of new car demand models for the U.S., 1976-1984

VARIABLE NAME	ESTIMATED COEFFICIENT	STANDARD ERROR	T-RATIO	P-VALUE
MODEL 1:				
PRICE	-1.6845	0,2408	-6,996	0,000
PCY	3,3250	0,6225	5,341	0,000
CSENT	0,27553	0.7960E-01	3,461	0,002
LGSTOK	1,8192	2,051	0.8870	0,383
Q1	0.53278E-01	0.2797E-01	1,905	0,068
Q2	0,13028	0.2903E-01	4,488	0,000
Q3	0.92829E-02	0.2813E-01	-0,3300	0,744
CONSTANT	-32,098	9,272	-3,462	0,002

R-SQUARE ADJUSTED = 0.8713
LOG OF THE LIKELIHOOD FUNCTION = 55.13

MODEL 2:

VARIABLE NAME	ESTIMATED COEFFICIENT	STANDARD ERROR	T-RATIO	P-VALUE
PRICE	-1.8589	0,6472	-2,872	0,008
PCY	4,2699	1,462	2,921	0,007
LGPRI	-0,14048	0.9331E-01	-1,505	0,144
LGUPL	0,15290	0,1803	0.8478	0,404
LGSTOK	2,5271	1,977	1,278	0,212
Q1	0.58663E-01	0.2673E-01	2,195	0,037
Q2	0,13614	0.2746E-01	4,958	0,000
Q3	0.13266E-02	0.2678E-01	0.4953E-01	0,961
CONSTANT	-43,071	14,34	-3,004	0,006

R-SQUARE ADJUSTED = 0.8834
LOG OF THE LIKELIHOOD FUNCTION = 57.51

Notes :

Model 1 :
Dt = a8 PRICEa1t PCYa2t CSENTa3t LGSTOK a4t-4 ea5Q1+a6Q2+a7Q3
Model 2 :
Dt = a9 PRICEa1t PCYa2t LGPRIa3t-1 LGUPL a4t-1 LGSTOKa5t-4 ea6Q1+a7Q2+a8Q3

With: Dt: new car sales/population; Pricet: new car price index; PCYt: real disposable income per capita; CSENTt: consumer sentiment index; LGSTOKt-4=one year lag of total car registration/population; LGPRIt-1: one quarter lag of prime rate; LGUPLt-1: one quarter lag of unemployment rate; Q1, Q2, Q3: seasonal dummy variables.

P-values are based on two-tail test.

TABLE 2
OLS estimation results of new car demand models for the U.S., 1976-1984

VARIABLE NAME	ESTIMATED COEFFICIENT	STANDARD ERROR	T-RATIO	P-VALUE
MODEL 2A:				
PRICE	-1.3412	0,2133	-6,287	0,000
PCY	3,1398	0,5973	5,257	0,000
LGPRI	-0,20663	0.5091E-01	-4,059	0,000
LGSTOK	2,2996	1,948	1,180	0,248
Q1	0.58111E-01	0.2658E-01	2,186	0,038
Q2	0,13403	0.2720E-01	4,927	0,000
Q3	0.60141E-02	0.2607E-01	0,2307	0,819
CONSTANT	-33,481	8,765	-3,820	0,001
R-SQUARE ADJ: 0.8847		LLF	: 57.04	
MODEL 2B:				
PRICE	-2,6372	0,3984	-6,619	0,000
PCY	6,2207	0,6927	8,980	0,000
LGPRI	0,37995	0.1012	3,754	0,001
LGSTOK	1,9614	1,986	0.9878	0,332
Q1	0.56964E-01	0.2732E-01	2,085	0,047
Q2	0,14290	0.2772E-01	5,156	0,000
Q3	-0.45469E-02	0.2711E-01	-0.1677	0,868
CONSTANT	-54,219	12,56	-4,315	0,000
R-SQUARE ADJ: 0.8780		LLF	: 56.05	

TABLE 3
FGLS estimation results of new car demand models for the U.S., 1976-1984

VARIABLE NAME	ESTIMATED COEFFICIENT	STANDARD ERROR	T-RATIO	P-VALUE
MODEL 1:				
PRICE	-1.8656	0,2435	-7,663	0,000
PCY	3,5860	0,5844	6,136	0,000
CSENT	0,30624	0.8362E-01	3,662	0,001
LGSTOK	2,8182	2,210	1,275	0,213
Q1	0.38144E-01	0.3990E-01	0,9559	0,348
Q2	0,12914	0.1929E-01	6,696	0,000
Q3	-0.25805E-01	0.4002E-01	-0.6448	0,524
CONSTANT	-39,932	9,978	-4,002	0,000

R-SQUARE ADJ: 0.9038

MODEL 2A:				
PRICE	-1,4185	0,1164	-12,18	0,000
PCY	3,0114	0,4416	6,819	0,000
LGPRI	-0,21579	0.3406E-01	-6,336	0,000
LGSTOK	3,1563	1,567	2,014	0,054
Q1	0.34368E-01	0.4663E-01	0,7370	0,468
Q2	0,13160	0.1731E-01	7,603	0,000
Q3	-0.16977E-01	0.4583E-01	-0.3704	0,714
CONSTANT	-37,227	6,135	-6,068	0,000
R-SQUARE ADJ: 0.9246				

Notes :

Model 2A : Dt = a8 PRICEa1t PCYa2t LGPRIa3t-1 LGSTOK a4t-4 ea5Q1+a6Q2+a7Q3

Model 2B : Dt = a8 PRICEa1t PCYa2t LGUPLa3t-1 LGSTOK a4t-4 ea5Q1+a6Q2+a7Q3

P-values are based on two-tailed test.

TABLE 4
FGLS estimation results of new car demand
for the U.S., 1976-1984
PANEL A : 1st qtr 1976-3rd qtr 1979
PANEL B : 4th qtr 1979-4th qtr 1984

VARIABLE NAME	ESTIMATED COEFFICIENT	STANDARD ERROR	T-RATIO	P-VALUE
		MODEL 1		
PANEL A:				
PRICE	1,2420	2,053	0,6048	0,567
PCY	0,10304	0,9711	0,1061	0,919
CSENT	0,84287	0.2080	4,052	0,007
LGSTOK	-0,17859	7,834	-0.2280E-01	0,983
Q1	-0.26288E-01	0.2180E-01	-1,206	0,273
Q2	0,17639	0.8839E-01	1,996	0,093
Q3	-0.80487E-02	0.8113E-01	-0.9921E-01	0,924
CONSTANT	-7,2704	44,54	-0,1632	0,876
R-SQUARE ADJUSTED = 0.9476				
PANEL B:				
PRICE	-1,9135	0,1116	-17,14	0,000
PCY	2,5942	0,4616	5,620	0,000
CSENT	0,72614	0.7857E-01	9,242	0,000
LGSTOK	-5,8674	1,138	-5.157	0,000
Q1	0.94467E-01	0.5592E-01	1,689	0,115
Q2	0,12065	0.1125E-01	10,72	0,000
Q3	0.48818E-01	0.5828E-01	0.8376	0,417
CONSTANT	6,271	3,516	0,004	
R-SQUARE ADJUSTED = 0.9353				

		MODEL 2A		
PANEL A:				
PRICE	1,4539	0,6209	2,342	0,058
PCY	-1,6269	0,5159	-3,154	0,020
LGPRI	-0.57093	0.2993	-1.908	0,105
LGSTOK	4,8732	0,9214	5,289	0,002
Q1	-0.54364E-02	0.5137E-01	-0,1058	0,919
Q2	0,11605	0.2113E-01	5,493	0,002
Q3	-0.25991E-01	0.2511E-01	-1,035	0,341
CONSTANT	-19,078	2,579	-7,397	0,000
R-SQUARE ADJUSTED = 0.9733				
PANEL B:				
PRICE	-1,4926	0.7467E-01	-19,99	0,000
PCY	3,3729	0,3612	9,339	0,000
LGPRI	-0,24186	0.2241E-01	-10,79	0,000
LGSTOK	1,7690	1,404	1,260	0,230
Q1	0.16107	0.6570E-01	2,452	0,029
Q2	0,11588	0.1611E-01	7,194	0,000
Q3	0.13321	0.6918E-01	1,926	0,076
CONSTANT	-31,462	6,148	-5,118	0,000
R-SQUARE ADJUSTED = 0.9161				

Note : P-values are based on two-tailed test.

TABEL 5
Forecast results of new car demand for the U.S., 1985

	MODEL 1				MODEL 2A			
	OLS		FGLS		OLS		FGLS	
Period: 1985.1								
Actual Dt	11,05							
Predicted Dt		10,59		10,65		10,64		10,47
% Difference		-4,16		-3,62		-3,71		-5,25
Forecast Interval	9,28	12,07	9,46	11,98	9,39	12,05	9,43	11,62
Period: 1985.2								
Actual Dt	12,42							
Predicted Dt		12,48		13,02		12,89		13,15
% Difference		0,48		4,83		3,78		5,88
Forecast Interval	10,86	14,34	11,41	14,85	11,25	14,76	11,78	14,67
Period: 1985.3								
Actual Dt	12,3							
Predicted Dt		10,29		10,53		10,91		10,93
% Difference		-16,34		-14,39		-11,30		-11,14
Forecast Interval	8,96	11,82	9,24	12	9,48	12,56	9,74	12,26
Period: 1985.4								
Actual Dt	10,09							
Predicted Dt		10,18		10,56		10,89		11,15
% Difference		0,89		4,66		7,93		10,51
Forecast Interval	8,85	11,71	9,24	12,08	9,42	12,58	9,9	12,55
RMSE		1,032		0,986		0,86		0,983
MAE		0,656		0,812		0,767		0,934
THEIL-U		0.0897		0.0857		0.0747		0,0854

Note : % Difference = 100 * (Predicted Dt-Actual Dt) / Actual Dt