The Demand for New Motor Vehicles

— Using Australian Consumer Sentiment Measures to Explain and Predict Consumer Behaviour

This article was prepared by J. S. McDonnell and Dr. L. V. Defris of the Institute of Applied Economic and Social Research. The authors are indebted to Dr. P. J. Sheehan for his helpful comments.

JS McDonnell & LV Defris, The demand for New Motor Vehicles, Australian Economic Review, Fourth Quarter, 55-64.

1. Introduction

In Australia, the Institute of Applied Economic and Social Research has conducted quarterly surveys of consumers' attitudes, expectations and buying intentions since January 1973. Only one rather preliminary study has been made by the same authors of the informational content of these surveys.[1]

The analysis of the demand for new motor vehicles, cars and station wagons, represents the first stages of the work on the *explanatory* and *forecasting* value of the Institute's Consumer Survey data.

This is part of a larger project, which will look at the usefulness of consumer sentiment data for explaining and forecasting total consumption expenditure, expenditure on both durables and non-durables, the level of savings and the demand for particular consumer durables.

In this article we present quarterly demand models of the Australian new car market, using consumer sentiment data, which has only been available from first quarter 1973. In the first part of the article, other studies of motor vehicle demand are briefly reviewed. We then proceed to outline the economic model used and look at attitudinal variables versus objective variables. The econometric analysis follows and is presented in two stages: first, purely attitudinal models and second, objective economic models combined with attitudinal variables. Finally, several important factors emerge from this study and are discussed in our conclusions.

2. Review of Studies of the Demand for Motor Vehicles

The demand for motor vehicles has been widely studied in the United States, United Kingdom, Canada and Australia. Many studies[2] explain and predict this demand purely in terms of such objective[3] economic variables as income, population, credit availability, relative prices and new model introductions. For Australia alone, there are eight objective variable models. With the exception of Rosendale, Nish, and Fisher and Taylor, these models arose from macro studies which included an equation for the demand for cars.

The models differ in four main ways. First, originally most models were annual models which have been converted to quarterly models for short-term forecasting purposes. Second, some models use consumer dollar expenditure on motor vehicles while others use physical quantities. Third, some models are single equation models while others are multi-equation models. Finally, differences arise due to the particular explanatory variables used. Frequently used variables include: income, population, credit availability, relative prices, the timing of new model introductions and stocks.

During the last 15 years a number of overseas studies have examined the role of consumer sentiment in explaining and predicting consumption expenditure whether in whole or in part. Among other things, the demand for motor vehicles[4] has received considerable attention. There are some long studies of motor vehicles for the United States, using data collected by the University of Michigan's Survey Research Centre. There have also been two for Canada, one for the United Kingdom and none so far for Australia. For the most part the overseas models are single equation models which use the Index of Consumer Sentiment or its counterpart (Composite Index of Consumer Mood — for Canada) as the measure of consumer sentiment.

Since the development of attitudinal surveys in the 1950's there has been significant controversy concerning the usefulness of these data for explaining and predicting consumer behaviour. However, as the number of observations increased, it became evident

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1
L. V. Defris and J. S. McDonnell, "Identification and Measurement of Australian Consumer Sentiment", *Australian Economic Review*, 2/76, p. 35-44.

2
See bibliography for both overseas and Australian studies.

3
As distinct from the subjective, attitudinal consumer sentiment data.

4
See Bibliography.

that aggregate consumption models, discretionary spending models, savings equations and indeed motor vehicle models which included measures of consumer sentiment were superior to purely objective models.[5]

3. The Economic Model

Katona's theory[6] simply states that consumption is a function of the ability to buy and the willingness to buy, where the ability may be indicated by variables such as income, the availability of credit and prices, and the willingness may be proxied by consumer sentiment measures. Therefore, we hypothesise that the demand for motor vehicles may be expressed as: NR = F (Ability to Buy + Willingness to Buy), where NR is new registrations of cars and station wagons as this is an analysis of the new car market only. Thus, we are postulating that new registrations or the demand for new motor vehicles in any quarter is a function of both the ability to buy (measured in terms of income, credit availability, relative prices), and willingness to buy (measured by our consumer sentiment data).

In the real word of course an effect often may only be produced by its cause after some interval of time. This gives rise to an observable 'lag' between a cause and its effects. In this article we take specific account of the likelihood of lags affecting the purchases of motor vehicles.

In assessing the explanatory and forecasting value of consumer attitudes, expectations and buying intentions data, it is necessary to examine these psychological variables both as *substitutes* for and *complements* to more objective economic variables.

Let us first look at their role as substitutes for economic variables.

Some attitudinal variables move directly in response to external economic factors and will therefore be correlated with certain objective economic variables. Thus, the appropriate attitudinal variables may be substituted for these economic variables and the events and effects which they summarise. This role as a substitute is particularly useful because of the ready availability of survey data. The collection and processing delay in the availability of Consumer Survey data can be as low as 2 weeks.

In acting as complements to economic variables, measures of consumer sentiment act out their role in Katona's theory. Attitudinal variables of this type have probably been formed by the interaction of real factors which could eventually be tracked back and measured. However, the interactions are extremely complex and generally uncharted. Also the original data are often not normally available. In any case in this instance, it is the attitude with which we are most directly concerned since such variables are of the *complementary* type and are indicators of Katona's 'willingness to buy'. It is the attitude which applies here and directly affects purchases and as such it is the attitude with which we are concerned, not the external (and other) factors which formed that attitude.

Since attitudinal variables may act in both capacities, it would be expected that some combination of them may satisfactorily explain the demand for motor vehicles. We would expect in this event that the role each variable was taking would not necessarily be obvious. A variable combining some of both influences is also quite possible.

In this article, models showing consumer sentiment data acting as *both* substitutes for and complements to economic variables will be presented initially. Later, models which treat sentiment data as complementary to more objective variables will be examined. The purpose of this second approach is to look at the *independent* contribution of attitudinal variables in explaining and forecasting consumption behaviour. However, both roles are of equal importance when forecasting.

Because of the results of our study of the informational content of the Australian Consumer Surveys,[7] we expected that some of the important factors affecting consumer behaviour would be the same as those which were shown to be important in this original analysis. These factors were consumers' views on both current and future levels of unemployment and inflation and their reporting of items of economic news.

4. Quarterly Models of New Registrations Using only Attitudinal Variables

(1) Available Attitudinal Variables

Numerous measures of consumer sentiment can be derived and constructed from Consumer Surveys data. In this analysis both naturally occurring variables and constructed variables are examined for their relative explanatory and forecasting ability in single equation quarterly models.

Very simply, the models may be specified as:

$$NR_t = f\ (S_{1t-i}, S_{2t-i} \ldots)$$

and

$$\Delta NR_t = f\ (S_{1t-i}, S_{2t-i} \ldots)$$

where $S_1 \ldots S_n$ are various consumer sentiment variables and i ranges from 0 to 4. Four separate types of Consumer Survey data are used in the empirical analysis —

(i) The Index of Consumer Sentiment — a summary of current consumer sentiment based on 5 survey questions.
(ii) Individual Attitudinal Questions
 — Favourable responses
 — Unfavourable responses
 — Differenced responses
(iii) Buying Intentions — proportions of respondents intending to buy specific consumer goods.
(iv) Indexes formed on the basis of the Principal Components analysis carried

5 E. Mueller, "Ten Years of Consumer Attitude Surveys: Their Forecasting Record", *Journal of the American Statistical Association*, Vol. 58 (1963), p. 899-917. F. Juster, "Consumer Anticipations and Models of Durable Goods Demand", *Economic Forecasts and Expectations*. A Report of the National Bureau of Economic Research. Columbia University Press, 1969. S. H. Hymans, "Consumer Durable Spending: Explanation and Prediction", *Brookings Papers on Economic Activity*, No. 2, 1970. H. T. Shapiro and G. E. Angevine, "Consumer Attitudes, Buying Intentions and Expenditures — An Analysis of the Canadian Data", *Canadian Journal of Economics*, Vol. 2 (1969), p. 236-49. G. E. Angevine, "Forecasting Consumption with a Canadian Consumer Sentiment Measure", *Canadian Journal of Economics*, 7 (1974), p. 272-289.

6 For a more detailed discussion of the theory behind consumer surveys see *Australian Economic Review* 2'76, p. 36-57.

7 L. V. Defris and J. S. McDonnell, *Australian Economic Review*, 2'76, p. 35-44.

out on Survey data by the authors.[8] Indexes may be formed from either *standardised* survey data (data treated so as to have a mean of zero and a standard deviation of one) or from non-standardised survey data (untreated data).

New registrations (NR) and changes in new registrations (ΔNR) are hypothesised to be functionally related to consumer sentiment both currently and with up to a four quarter lag.

The reason we anticipate lags a priori, is that the structure of many Consumer Survey questions is such as to suggest a lead-time. They involve answers to questions about the future or about things that indicate future developments. They provide data that gives a short look ahead into consumer behaviour.

(2) Methodology and Criteria

The analysis has been based throughout on a simple multiple linear regression model of the form:

$$NR_t = B_0 + B_1 X_1 + B_2 X_2 + \ldots B_n X_n$$

(. . . similarly for ΔNR_t)

Since there were only fourteen observations de-seasonalised data was used wherever necessary. This approach was preferred to the use of dummy variables, in order to preserve the degrees of freedom available for the analysis. Since it was desired to introduce lags into the consumer sentiment measures with an implied loss of observations equal to the lag, it was decided to use leads in the new registrations of one to four quarters instead, thereby maintaining the 14 observations available.

In evaluating the various equations, reference will be made to four indicators of the significance of an equation. These criteria will be the following:

(a) R^2 — the coefficient of determination and $\bar{R}^2$ which allows for the number of variables in a regression relative to the number of observations.
(b) The Durbin-Watson statistic (DW).
(c) t values of parameters — a test of the significance of each variable.
(d) Mean absolute deviation.

R^2 measures the proportion of the total variation in the dependant variable which is accounted for by its relationship with the independent variables.

Besides explaining a good proportion of the variability in the data however, it is a statistical requirement that the residuals between the model's estimates and the actual data be randomly distributed. A systematic bias in the residuals of a model will show up if there is

(a) incorrect specification of the form of a model
(b) incorrect specification of lags
(c) omission of certain explanatory variables.

To test the hypothesis that there is no serial correlation in the residuals the DW must fall within a certain range. If not the model should be reviewed, since serious serial correlation casts doubts on the usefulness of the fitted equation.

The mean absolute deviation is the average of the residuals of an equation and is calculated by averaging the residuals' absolute values.

(3) Initial Results

(a) The Index of Consumer Sentiment

In the first stage of the analysis the Index of Consumer Sentiment and changes in the Index were examined in relation to new registrations and changes in new registrations. The results are set out in Table 1 below. The correlations between NR, ΔNR and ICS, ΔICS were not particularly high.

Table 1: The Relationship Between New Registrations and the Index of Consumer Sentiment 1/1973 to 2/1976

	ICS $\bar{R}^2$	ΔICS $\bar{R}^2$
NR_t	0.0080	0.0268
NR_{t+1}	0.0059	0.3048
NR_{t+2}	0.2695	0.0017
NR_{t+3}	0.3012	0.4807
NR_{t+4}	0.0076	0.1953
ΔNR_t	0.1410	0.1233
ΔNR_{t+1}	0.0009	0.1117
ΔNR_{t+2}	0.1249	0.1582
ΔNR_{t+3}	0.0025	0.3906
ΔNR_{t+4}	0.3089	0.0255

(b) Individual Attitudinal Questions

NR and ΔNR, leading zero to four periods were then correlated with individual attitudinal questions, in terms of favourable, unfavourable and differenced responses. The resulting correlation coefficients were then closely examined.

It was found that for new registrations the largest r values occurred with a 3 and 4 quarter lag on the attitudes, with concentration mainly on the 3 quarter lag. Some individual attitudinal questions had very high correlation coefficients of up to 0.8.

(c) Buying Intentions Questions

With respect to the individual buying intentions questions, some interrelations between NR and buying intentions for houses, cars and other durables was found. However, the correlation coefficients were much lower than for the individual attitudinal questions. This was also the case for buying intentions indexes which were formed on the basis of principal components combining of the various buying intention rates for different consumer goods.

(d) Attitudinal Indexes

Attitudinal indexes, using principal components weights, were constructed.[9] There were two types of index: first, the non-standardised form results from principal components analysis where allowance is made for the use of the mean only and second, the standardised indexes in which weights are determined after allowance was made for both means and standard deviations. Both these groups of indexes showed that 3 and 4 quarter lags were again the most important.

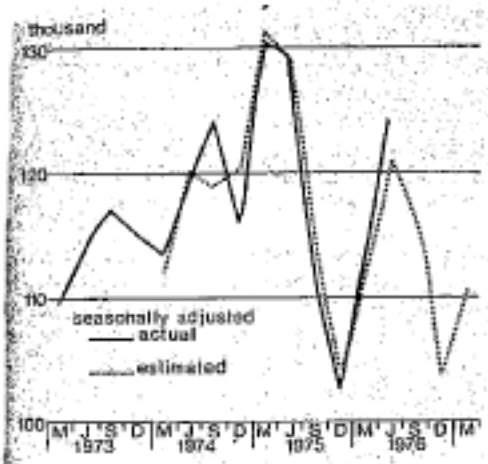
(e) Conclusions

In all cases it was found that sentiment was most highly related to *levels* of new registrations rather than changes in those levels.

8
L. V. Dotris and J. S. McDonnell, in *Australian Economic Review*, 2'76, p. 35-44.

9
For details of the construction of these indexes see L. V. Dotris and J. S. McDonnell, *Australian Economic Review*, 2'76, p. 35-44.

Chart A. Model 1



Whereas models in terms of changes were constructed, these had significantly less explanatory power than models in terms of levels of new registrations and will not be presented here.

As a result of these initial partial correlations it became evident that the analysis of the level of new registrations should continue in two main areas: first, the individual attitudinal questions and second, the standardised attitudinal indexes. The resulting models will be presented in the following two sections.

(4) Model 1 — Based on Individual Attitudinal Questions

Models were formulated of favourable, unfavourable and differenced responses, combining variables that had high r values but that were not correlated with each other. If they were intercorrelated the problem of multicollinearity would be encountered. (Multicollinearity occurs when the variables move together so closely that it is impossible to isolate their independent contributions.) Model 1 was developed from these combinations of responses to individual attitudinal questions.

The model states that new registrations in period t are a positive function of the news items ratio 3 quarters earlier, a negative function of unfavourable evaluations of the current unemployment situation 4 quarters earlier, and a positive function of unfavourable expectations of the rate of inflation 4 quarters earlier.

In this equation all the variables are significant at the 5 per cent level; the R^2 is reasonably high; the DW is too high, suggesting there is some negative serial correlation in the model. However, the residuals are extremely good with small percentage errors. The mean absolute deviation is 2031 cars.

Chart A compares actual new registrations with predicted registrations on the basis of 3 and 4 quarter lags in attitudes.

Model 1

$$NR_t = \underset{(3.8)}{57.70} + \underset{(3.4)}{3.11}\, U/F12_{t-3} - \underset{(-3.4)}{0.17}\, U8_{t-4} + \underset{(3.5)}{0.67}\, U11_{t-4}$$

$\bar{R}^2 = 0.875$ D W = 2.67

Mean Absolute Deviation = 2031 cars

where U/F12 is the ratio of unfavourable to favourable news items (question 12);

U8 is the proportion of respondents who evaluate current unemployment unfavourably (question 8);

U11 is the proportion of respondents who hold unfavourable expectations as to the rate of inflation.

The Sales Tax Cut

Because the sales tax reduction on motor vehicles in February 1975 was so effective, a dummy tax variable was introduced into model 1 of the form 1/1975 = +1, 2/1975 = +1, 3/1975 = −1, 4/1975 = −1 and for other quarters zero.

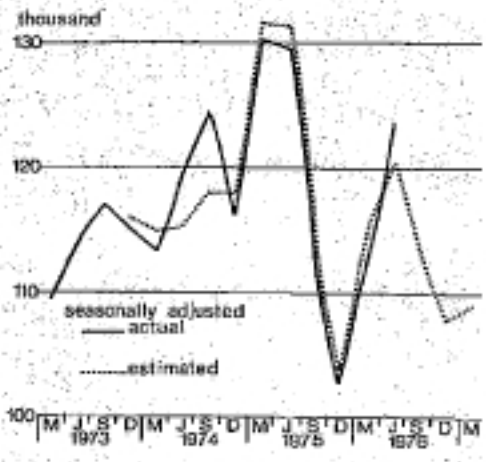
However, in this model, it was *not* significant; that is, the attitudinal variables appeared to be doing the work of the ta dummy.

Table 2. Attitudinal Model Forecasts of Registrations of New Cars and Station Wagons

	Seasonally Adjusted		Including Seasonal Factors	
	Model 1	Model 2	Model 1	Model 2
1976/3	115,960	113,390	118,682	116,112
1976/4	103,940	107,760	105,451	109,271
1977/1	110,630	109,010	102,518	100,898

Note: Seasonal adjustment factors derived from figures published by the Australian Bureau of Statistics.

Chart B. Model 2



(5) Model 2 — Based on Standardised Atti tudinal Indexes

Model 2 uses the sales tax dummy variabl along with standardised indexes. An inde which had previously been included wa found to be redundant when the tax dumm was introduced. In this equation standardise Indexes I_1 and I_2 were significant at the 5 pe cent level, I_4 at the 10 per cent level. Index I closely resembles the news items ratio, I, the evaluation of unemployment, and I_4, buy ing intentions for new cars. These variable are very similar to the variables in model 1 The $\bar{R}^2$ is still reasonably good but lower tha in model 1. The DW is lower so there doe not appear to be serial correlation in th residuals, which are fairly small, recording mean absolute deviation of 2327 cars. Char B shows the actual and predicted values o new registrations using model 2.

Model 2

Standardised Indexes

$$NR = \underset{(27.1)}{116.16} - \underset{(-4.1)}{1.649}\, I_{1\ t-3} + \underset{(3.4)}{1.461}\, I_{2\ t-8} - \underset{(-2.0)}{1.514}\, I_{4\ t-4} + \underset{(2.6)}{5.705}\, DT_t$$

$\bar{R}^2 = 0.83$ D W = 1.73

Mean Absolute Deviation = 2327 cars

The forecasts of both model 1 and model 2 are set out in Table 2.

Table 3. Intercorrelations of Survey and Economic Variables

Variable	$HDYR_t$	U/V_t	$\frac{MVP}{CPI_t}$	Variable Name
	Correlation coefficients			
		Model 1		
$U/F12_{(t-4)}$	0.4181	0.4129	−0.1507	News Items Ratio
$UB_{(t-3)}$	0.4186	0.6636	0.8316	Evaluation of Unemployment
$U11_{(t-3)}$	0.1706	0.2218	−0.2235	Expected Inflation
Index		**Model 2**		**Index Make-up**
$I_{1\ (t-3)}$	0.4405	−0.3896	−0.0783	News Items Ratio
$I_{2\ (t-3)}$	0.3280	0.7265	0.8340	Evaluation of Unemployment
$I_{3\ (t-4)}$	0.1712	0.1494	−0.3212	Expected Inflation
$I_{4\ (t-3)}$	0.4268	0.2204	0.5127	Buying Intentions for New Cars

(6) Intercorrelations of Consumer Sentiment Variables and Economic Variables

If consumer sentiment data is to be used alone it is important to establish the relationship discussed earlier between traditionally accepted and useful economic data and the consumer sentiment variables.

Table 3 shows the intercorrelations between the consumer sentiment variables of models 1 and 2 and the typical economic variables of, for example, Filmer and Talbot, and Nish.

The table shows clearly the reasons for obtaining such good results with the attitudinal models. The correlation between the evaluation of unemployment and the relative price of motor vehicles is 0.83; the evaluation of unemployment is also highly correlated with the unemployment/vacancies ratio. Similar results are obtained for the news items ratio which shows some correlation with income and the unemployment/vacancies ratio. Expected inflation is not highly correlated with the economic variables. The index variables used in model 2 also show some high correlations with unemployment and relative prices and to a lesser extent with income.

It is important to stress that this table highlights two important features: first, that consumer sentiment variables are useful, in part, as good substitutes for economic variables and second, that they have a considerable and useful lead time over economic variables.

5. The Role of Objective Variables in Anticipatory Models

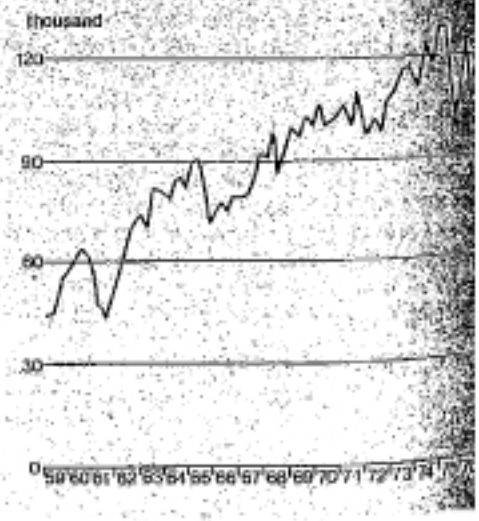
(1) Initial Theoretical Considerations

The forecasting models that have so far been outlined utilise solely consumer attitudinal data. Only models which maximise the proportion of variance in new registrations that can be explained by using consumer sentiment data alone have been constructed. At this stage we will incorporate objective economic variables into our models in an attempt to isolate in part the independent influence of consumer sentiment on fluctuations in durable demand. However they will be allowed to remain in a model only if they make a significant contribution to the explanatory power of that model. If they fail this test their role may be taken by an attitudinal variable. Our period of analysis is generally restricted to a fairly unusual and turbulent 14 quarter period and thus many quite reasonable variables could fail to prove to have a significant effect on motor vehicle sales in this short term.

Chart C, which traces seasonally adjusted quarterly registrations from 1959, shows that our 14 quarter period may be taken to be not untypical of the entire period, that is, trend factors appear to exert a continuing influence on new registrations. On the other hand it could also be argued from the chart that this period is quite untypical of the longer period and there was during 1973 a *step* upwards in demand which has since plateaued and, right up to the present time, trend factors [illegible] had little or no influence on the demand [illegible] motor vehicles.

Whichever hypothesis is considered [illegible] more acceptable it would be unlikely that [illegible] separate influences of long term trend factors such as real income could be isolated [illegible] the short term factors such as changes [illegible] consumer sentiment. If this is true then [illegible] can allow for long term trend factors [illegible] estimating their effects over a much longer period and then removing these effects before looking at current short term factors. In the first alternative presented below we assume this to be true and proceeded with the analysis by calculating the long term trend [illegible] inspecting a number of possible trend variables. The trend effects were then removed and the resultant residuals were analysed in the light of consumer sentiment data. In the second alternative we did not make the assumption and tested several likely economic variables over the short term in conjunction with consumer sentiment data. That is we ran regressions over our 14 quarter period which tested various lagged combinations (in the one equation) of trend variables and principal component sentiment indexes.

Chart C. Quarterly Registrations of New [illegible] and Stationwagons seasonally adjusted



(2) The First Alternative

One approach to developing a forecasting model suggests the hypothesis that there is an underlying trend in motor vehicle sales, resulting largely from population growth and increasing income per head. This trend should first be removed and then the attitudinal survey data used to explain the movements around this trend. However we must look to the longer term since it is unlikely that the trend factors which caused the growth evident in the graph will be identifiable in the short term.

The data used dates back to 1959 to include the 1961 recession and the events leading up to it. The data consisted of 69 observations as some economic data was only available up to 1/1976. Seasonally adjusted data were used throughout.

In this section, since we are only detrending data on the basis of the long term trend we are expecting the consumer survey data to act in the capacity of both substitute for and complement to economic variables in the short term. That part of the fluctuations in new registrations which is not dependent on the long term trend factors will be explained by the short term sentiment variables.

	Actual	Predicted	Residual	% Error
1973				
1	111,349	111,906	−557	0.5
2	114,358	112,298	2060	1.8
3	117,287	112,684	4603	3.9
4	115,068	114,026	1042	0.9
1974				
1	113,652	115,610	−1958	1.7
2	118,909	116,288	2621	2.2
3	124,365	116,839	7526	6.1
4	117,071	118,262	−1191	1.0
1975				
1	130,244	119,449	10795	8.3
2	129,432	119,618	9814	7.6
3	111,949	119,816	−7867	7.0
4	102,819	120,771	−17952	17.5
1976				
1	113,156	121,177	−8021	7.1
2	124,057	121,639(a)	2418(a)	1.9

(a) calculated from a population estimate for 2/1976.

Table 4. The Regressions of New Registrations and Objective Economic Variables

		Variables									$\bar{R}^2$
		POP	REAL W+S/H	U/V_t	U/V_{t-1}	U/V_{t-2}	REAL HDY	U/V_{t-3}	M V PRICES	LGS	
Run	(1)	X^s	X								0.90
	(2)	X^s	X	X^s							0.91
	(3)		X^s	X							0.81
	(4)		X^s		X						0.81
	(5)		X^s			X					0.81
	(6)					X^s	X^s				0.82
	(7)				X^s		X^s				0.82
	(8)	X^s					X	X			0.89
	(9)						X^s		X^s	X^s	0.83
	(10)	X^s				X			X		0.90
	(11)	X^s									0.89
	(12)	X^s							X^s		0.90
	(13)	X^s								X	0.89

Table 4 sets out the economic variables that were used in the trend tests, with X^s indicating whether the variable was significant in the particular regression and X showing that it was included but not significant.

The trend equation still requires further work, particularly with regard to the leads and lags. The DW is fairly low on all these equations which indicates that there is positive serial correlation and this may be due to lagged relationships.

However, the $\bar{R}^2$'s are quite high and equations 11 and 12 will be examined further.

Equation 11 uses population as the only explanatory variable. This equation appeals as an uncomplicated way of detrending motor vehicle sales because it is fairly easy to predict for forecasting purposes, it has a high $\bar{R}^2$ and wipes out other trend variables when they are included in an equation with it, since it dominates the relationship. Equation 11 may be written as

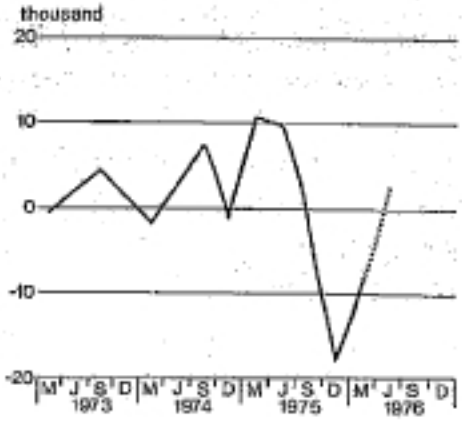
$$NR_t = -142{,}862 + 1.9415\ \text{Population}_t$$
$$(-14.7) \qquad (23.8)$$
$$\bar{R}^2 = 0.89 \qquad D\,W \doteq 0.63$$
$$\text{Mean Absolute Deviation} = 5602$$

This equation summarises the trend factors using population alone and when applied over our 14 quarter period yields the following 'predictions' and consequent residuals from actual new registrations. The residuals average out to be 5602 in error over the period.

Chart D graphs these residuals and shows the strong effect of the 1975 tax cuts in pulling sales forward to the first half of 1975 from the second half of that year. In addition if the trend growth in registrations evident since 1959 is still continuing, sales during 1973 and 1974 were generally well above trend.

Thus far all that has been done is to use equation 11 to detrend new registrations. The next step in the analysis is to explain

Chart D. Residuals from Population Trend



the residuals of equation 11 in terms of consumer survey data. To this end both standardised and non-standardised indexes for favourable, unfavourable and differenced responses were examined for their correlations with new registrations.

As in the models discussed earlier in the article, the indexes with 3 and 4 quarter lags proved to be the most highly correlated. In other words the effects of consumer attitudes are reflected in new registrations 3 or 4 quarters later.

A dummy variable was introduced to allow for the effects of the tax cut in the first half of 1975. This proved a very successful variable, which however, forced many of the indexes into insignificant roles.

The most successful combination is detailed below. It consists of standardised index 2 and index 4 constructed from differenced responses to survey questions, lagged 3 quarters. The equation has a high $\bar{R}^2$ of 0.82.

All the variables are significant and the DW indicates that serial correlation is no longer present. The mean absolute deviation or the average amount by which we are amiss in estimating new registrations for the past 14 quarters is 2469 cars or just 2 per cent of quarterly registrations.

$$NR_t = -1342.6 + \underset{(3.3)}{7696DT_t} - \underset{(-2.0)}{1721.7\ PC2_{t-3}} - \underset{(-2.3)}{2290.8\ PC4_{t-3}}$$

$$\bar{R}^2 = 0.82 \qquad D\ W = 2.1$$

Mean Absolute Deviation = 2469 cars.

Looking back to Table 4 we see that equation 12 is another successful trend equation. It includes a variable for motor vehicle prices relative to the consumer price index as well as population and has an $\bar{R}^2$ of 0.90.

Equation 12 may be written more explicitly as:

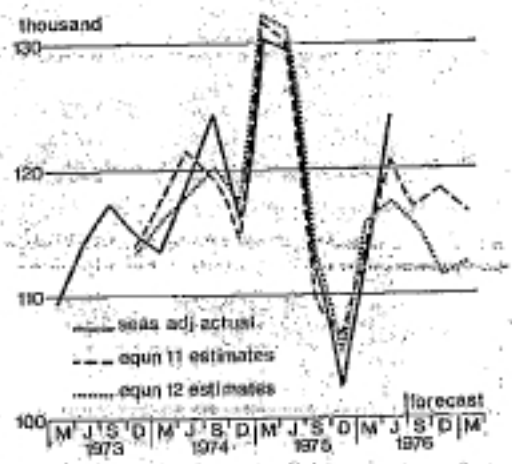
$$NR_t = -145{,}236 + \underset{(-15.4)}{2.1075\ \text{Population}} - \underset{(2.5)}{15.4112\ \text{M V Price Index}}$$

$$\bar{R}^2 = 0.90 \qquad D\ W = 0.66$$

Mean Absolute Deviation = 5314

In equation 12 all the variables are significant at 5 per cent level, the $\bar{R}^2$ is high at 0.90 but the DW is very low indicating significant positive serial correlation. The mean absolute deviation is high at 5314 cars.

Chart E. New Registrations of Cars and Stationwagons



When examining the residuals the best explanatory factor was the single Favourable non-standardised index, PC1, lagged 3 quarters, and this is incorporated in the following equation:

$$NR_t = 2815.5 + \underset{(3.5)}{7393\ DT_t} - \underset{(-2.3)}{164.0\ PC1_{t-3}}$$

$$\bar{R}^2 = 0.78 \qquad D\ W = 1.68$$

Mean Absolute Deviation = 2769 cars

This equation also has a fairly high $\bar{R}^2$ of 0.78. The D W indicates no serial correlation and the typical size of the deviation is 2769 cars, higher than in any of the other models.

Forecasts

In order to forecast new registrations from these models it is necessary to first forecast the population. For these forecasts, population growth was estimated at 0.175 per cent per quarter or 0.7 per cent per annum.

Forecasts of the relative price of motor vehicles were also necessary. For the purposes of the exercise the forecasts used were 3.7 per cent in September, and 2.2 per cent thereafter. The September figure is inflated by the increases due to the introduction of emission controls although this change could also be treated as a quality change. Once again the figures were adjusted by the ABS seasonal factor. The forecasts seasonally adjusted and otherwise are set out in Table 5.

Chart E sets out actual and predicted registrations by these two models, showing also the forecasts outside the time period analysed.

(3) The Second Alternative

In this section we test an assumption made earlier, that trend factors affecting registrations would not show up in the short term and that we would need to go to a longer term in order to estimate their effects.

If economic variables are to be included directly in a short term demand equation, the theory that ability to buy and willingness to buy both operate at the one time means that both types of variables should be included in the one equation. Thus objective economic variables should be tested along with consumer survey data in a series of regressions to determine the most satisfactory combinations. Various combinations of lagged economic data were tried together with the most successful of the sentiment indexes. The economic variables of Table 3 were those which were tested in regression analysis over the 14 quarters to the second quarter 1976.

As we had suspected, long term trend factors such as household disposable income and population became insignificant in these relationships, their part being taken up by the constant term. Only if this was excluded do they become significant. One variable which consistently emerge was the ratio of the motor vehicle price index and the consumer price index lagged 4 quarters. This variable would obviously assume even greater importance

Table 5. Forecasts of Registrations of New Cars and Station Wagons on Models based on Equation 11 and Equation 12

Quarter	Seasonally Adjusted		Including Seasonal Factors	
	Equn 11	Equn 12	Equn 11	Equn 12
3/1976	116,857	115,353	119,579	119,0[illegible]
4/1976	117,490	111,402	119,001	112,8[illegible]
1/1977	116,519	112,456	108,407	104,[illegible]

Table 6. Forecasts of Registrations of New Cars and Station Wagons

	Seasonally Adjusted	Including Seasonal Factors
1976/3	111,271	113,993
1976/4	109,382	110,893
1977/1	107,833	99,521

we gather more observations and the time period is lengthened, as it was also a significant variable in equation 12 of the previous section, which of course dealt in the longer term. However, this variable would not be seen as a *long term trend* variable. Rather it is one which causes some of the quite large short term adjustments seen over the period.

Thus, here we see more of the independent complementary contribution of consumer sentiment data becoming evident. Some of the factors which determine 'ability to buy' are having a significant measurable effect on new registrations. In the final equation below we only end up with motor vehicle price effects but they are particularly interesting because they are doing a job similar to that of the sentiment variables earlier. They are acting in both capacities. In other words while increases in motor vehicle prices for a given level of income would undoubtedly affect the ability of people to buy cars, a change in their price would also have an effect on willingness to buy.

The equation below presents one successful combination of economic and sentiment variables. All variables are significant at the 5 per cent level. While the $\bar{R}^2$ of 0.85 is satisfactory, a DW of 2.6 is inconclusive. A tax dummy is included. The sentiment variables are the two which appear in the equation 11 model of the previous section. They are the second and fourth indexes formed from standardised differenced responses to survey questions.

The forecasts of this model are given in Table 6.

$$NR_t = \underset{(7.9)}{198.203} + \underset{(3.1)}{6.328}\, DT_t - \underset{(-2.9)}{1.537}\, PC2_{t-3} - \underset{(-2.6)}{2.316}\, PC4_{t-3} - \underset{(-3.3)}{92.230}\, MVP_{t-4}$$

$$\bar{R}^2 = 0.85 \qquad DW = 2.6$$

Mean Absolute Deviation = 2300

6. Conclusions

It is clear that much research still needs to be done in testing the predictive value of consumer sentiment data yielded by the Institute's Survey of Consumer Attitudes. Analysis is at present inhibited by the shortness of the time series available. It is therefore important to emphasise that even this study is still in its infancy, since the results have not been tested for their stability, accuracy and adaptability over a reasonable time period. We have presented 5 different models, any one of which could prove to be the most stable and adaptable in a changing environment. Even these 5 are by no means complete but it is felt that these approaches are promising.

At this stage in the development of forecasting models of the demand for durables the analysis leads to several important conclusions.

(1) It has been shown that Australian measures of consumer sentiment, derived from the quarterly surveys of consumers are capable of explaining a significant part of the variation in the demand for new passenger vehicles in the short term.

This has been the case both with the purely attitudinal models which were posed as substitutes for purely objective models and the combined objective-attitudinal models, where the consumer sentiment data acted in its more correct theoretical role, as a complement to economic variables in providing measures of consumers' willingness to buy durables.

(2) Whereas most previous studies, in the United States, the United Kingdom, and Canada which included data on consumer sentiment used the Index of Consumer Sentiment or its counterpart, we have utilised a number of other measures of consumer sentiment. The results support the case for consumer attitudes as expressed in individual questions and attitudinal indexes as the key consumer sentiment measures for explaining and predicting registrations of new cars and station wagons.

Some other possible measures such as buying intentions and the buying intentions indexes were not so highly correlated. The Index of Consumer Sentiment also seemed less relevant to this project than some of the other measures.

Indeed, single attitudinal questions c cerning the evaluation of unemploym expectations of inflation and the news it ratio were found the best measures of c sumer sentiment for explaining and predic the demand for new motor vehicles i purely attitudinal model. Similarly the i fudinal indexes representing the news it ratio, evaluation of unemployment, expec tions of inflation and buying intentions cars were found to be best in this context

In the mixed models the relevant sta ardised indexes best represent the evaluat of unemployment and buying intentions new cars; the non-standardised index p closely reflects expected unemployment.

(3) Most models in the past have focused examining the usefulness of attitudinal va ables in a more *ad hoc* context, perhaps ju adding on the Index of Consumer Sentime to a well-developed objective model. In th study the value of consumer sentiment da has been examined more systematically.

(4) Both the attitudinal and combined mode provide strong competition in terms of e planatory power to the more complex obje tive models and the potential predictive valu of the equations shown here are good sinc they include several lags. This means th unlike most objective models, the models pr posed here generally do not need to initial predict values for their independent variable before forecasting new registrations.

(5) Whereas many overseas studies try to ex plain consumer sentiment (that is, the inde of Consumer Sentiment) in objective term we have not done this, since we have man measures of consumer sentiment and th importance and composition of these will var according to the type of economic behaviou we are trying to explain and predict.

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