FORECASTING CAR OWNERSHIP

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ABSTRACT: *Accurate estimates of future car ownership are important because the level of car ownership is a primary determinant of personal mobility, modal split, total vehicle miles of travel and energy use in the transport sector. Different methods of forecasting car ownership are reviewed and their forecasts compared.*

Income and the cost of motoring are suggested to be the key explanatory variables with minor influence from saturation effects. Public transport availability may be an additional important factor for urban areas. As the unit of ownership is commonly the household, forecasting household car ownership rather than on a per capita basis may be more behaviourally consistent and allows consideration of the difference between the marginal utilities of the first and subsequent cars within a household. A summary of some earlier unpublished work presents a model, and its results, for forecasting urban car ownership using these ideas. Extensions of this model are proposed to forecast total car ownership. These extensions take into consideration the effects of differences in household structure and location and the causes and consequences of a move to smaller cars. While no completely formulated and calibrated model is put forward, a framework is presented which may suggest future research work using data from the 1976 Census.

1. INTRODUCTION

The future levels of car ownership are of considerable interest to many sections of society. The level of car ownership is the main determinant of personal mobility and total vehicle miles of travel (Burke et al 1972, Chaffin 1976). With the motor car as one of the more energy intensive modes of transport, future energy requirements in the transport sector are also primarily determined by the number of cars. When evaluating road and future transport policy alternatives, forecasts of modal split are important with modal split itself being largely influenced by patterns of car ownership. Forecasts of car ownership are also of obvious interest to the vehicle manufacturing industry.

The impact of the energy crisis, sharply increasing motoring costs, a growing awareness of public transport, pollution and the approach of saturation effects have rendered conventional forecasting methods, based on simple extrapolation, inadequate. The Australia of the sixties and early seventies, which has seen a steady growth in the number of cars from two million in 1960 to over five million in 1976 (Figure 1), may significantly differ from the Australia of the future. In order to make long term forecasts of patterns of car ownership a model including the main causal parameters is required. Such a model would allow the examination of the sensitivity of forecasts to different scenario assumptions.

Research in the area has not been extensive. The only immediate use of such forecasts has been for the allocation of federal government funds for roadbuilding, although the importance of accurate car ownership forecasts in urban transportation studies may well have been underestimated. Another important reason for the limited research has been the scarcity of suitable data. Some cross-sectional data has been collected by the Sydney, Melbourne and Geelong transportation studies which allows the analysis of the effect of household income on car ownership. The 1976 National Census includes a question on household income for the first time. This new source of data, together with the increasing importance of a national energy policy, should stimulate research in this field.

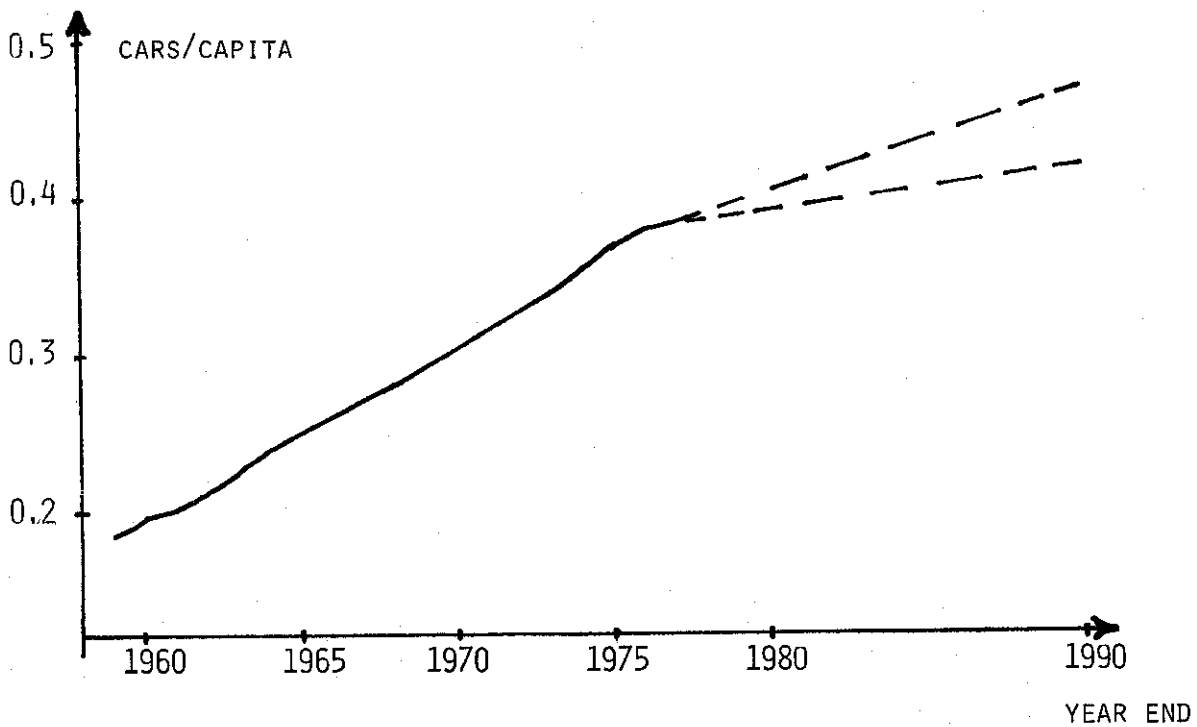

FIGURE 1 CAR OWNERSHIP IN AUSTRALIA

The paper reviews different methods of forecasting car ownership (Section 2). Limitations of trend extrapolation techniques are set out and the basic structure of a proposed model is put forward (Section 3). Section 4 presents a summary of the construction of an urban car ownership model which includes the provision of public transport as an explanatory variable. The causes and consequences of the trend to smaller cars are discussed in section 5 and conclusions, with recommendations for future research, are presented in Section 6.

2. REVIEW OF METHODS FOR FORECASTING CAR OWNERSHIP

The state of the art of forecasting car ownership in Australia is briefly examined. Some models use income and costs as causal factors while others take a time series approach. Several models also use an absolute saturation level of car ownership as a parameter, with this value being usually determined independently. Four basic models are considered.

2.1 LOGISTIC CURVE MODELS

The logistic function has the basic property that the rate of change of the level of ownership is proportional to the level of ownership itself and to the distance from this level to saturation. Two logistic curve models are examined, one which is based on purely time series and the other which uses per capita disposable income and motoring costs as the exogenous variables.

The Department of Transport & Shipping (1964) and Tanner (1974) assume that the level of car ownership will be given by a logistic function using time as the independent variable.

$$F = \frac{S}{1 + ae^{-bt}} \qquad \text{——— 1}$$

where F is the level of car ownership (cars per capita)
S is the saturation level
t is the time variable
and a and b are constants

Chaffin (1976) assumes that the progress of the level of car ownership along the logistic function will be determined by a measure of income relative to motoring costs.

$$F = \frac{S}{1 + ae^{-bY/C}} \qquad \text{——— 2}$$

where Y is real disposable income per capita costs
C is a real motoring costs index
and other parameters are as given in model 1

2.2 PARABOLIC CURVE MODEL

This method assumes that the level of car ownership can be modelled by a time dependent parabolic curve of the form:-

$$F = (a + bt)^{\frac{1}{2}} \qquad \text{——— 3}$$

2.3 I.A.C. MODEL

This is a stock adjustment model (IAC 1974) where the stock is a measure of the "services" provided by cars and station wagons rather than the actual number of them. Fundamental assumptions of the model are that more services are provided by a new car compared to those by a similar car of earlier vintage and that an expensive car provides more services than a cheap one. The services demanded in any one year are assumed to depend on personal income as well as the real cost of motoring. It suggests that with increasing real income people will demand more services but not proportionally more cars (i.e. people will buy better quality cars). The desired stock of services per capita Q^* is given by:-

$$Q^* = A_o + A_1 Y - A_2 C \qquad \text{——— 4}$$

Where A_o, A_1 and A_2 are positive constants.

The actual stock of services, and therefore the number of cars, is a lagged function of Q^*.

2.4 COMPARISON OF RESULTS OF MODELS

An exercise was carried out to determine how well each of the models could be fitted to past data and also to compare forecasts by each of the models for the level of car ownership in 1990. The period of calibration was 1962/63 to 1974/75, giving 13 data points. The comparison of "goodness of fit" of the models was based on the actual and predicted values of car ownership. A saturation level of 0.5 was used for both logistic curve models. The I.A.C. model was not recalibrated. The measure of goodness of fit used was the coefficient of variation (i.e. the standard error of the estimates expressed as a percentage of the mean of the estimated values). Therefore a lower value of the coefficient would indicate a better fit. Table 1 shows this value for each of the models.

Logistic (Time)	Logistic (Income/Cost)	Parabolic	I.A.C.
1.00%	3.30%	1.66%	1.24%

TABLE I

COEFFICIENTS OF VARIATION FOR FOUR MODELS

All models fit the data very well, the worst fit being seen in the second model where the standard error is still only 3.3% of the mean value. This analysis suggests that in terms of goodness of fit there is little to choose between the models. These results reflect the fact that in the past the growth in car ownership has been well behaved and a choice of models can be used to describe its past growth.

The models were then used to forecast the level of car ownership in 1990 (Table 2). Two forecasts have been produced for the IAC model; the first (A) has taken their most likely assumption of a continuing 1% p.a. decline in real costs while the second (B) has assumed an increase of 1% p.a. in costs and fifty percent higher petrol prices by 1980. The published IAC results to 1980 were extrapolated a further ten years. The latter assumptions on the movement of costs were made for the Income/Cost Logistic Model.

Logistic (Time)	Logistic (Income/Cost)	Parabolic	I.A.C.	
			A	B
0.460	0.416	0.476	0.467	0.420

TABLE 2

FORECAST CAR OWNERSHIP IN 1990

On the basis of past trends growth of car ownership will continue, but at a lower rate than in the past. In addition if costs were to increase in real terms then a substantially lower growth rate is forecast (Figure 1).

3. PROPOSED MODEL STRUCTURE AND COMPONENTS

3.1 LIMITATIONS OF TIME SERIES EXTRAPOLATION TECHNIQUES

The past rate of growth of car ownership in Australia has been very stable. As we have seen it is possible to calibrate successfully many different models of car ownership. Unfortunately the measure of goodness of fit to past data is not a stringent criterion of the quality of such a model. Consider the time-series models. While they are, without doubt, convenient to construct, there are two good reasons to question their use. In excluding any causal parameters it is not possible to use them to estimate the sensitivity of forecasts to different socio-economic scenarios. Thus the effects of a lower rate of GDP or of higher petrol prices cannot be quantified. Secondly the prime assumption in the use of simple extrapolation techniques is that the relationships which have existed in the past will continue into the future. This is a questionable assumption when considering long term forecasting models. Indeed there are good reasons to believe that socio-economic conditions in Australia are changing rapidly.

- Economic growth in Australia and the whole world may be slower than in the sixties and early seventies.

3.2

- Steadily rising real wage costs, a lower immigration rate of unskilled labour, the lack of rationalisation within the vehicle manufacturing industry and a continuing policy of import protection has led to rapidly increasing real prices of new cars over the past two years. This trend, which is in sharp contrast to that of the period up to 1973, may well continue.
- Third party and comprehensive insurance rates also have risen quickly.
- The OPEC oil price rises and declining domestic oil reserves will inevitably lead to substantially higher petrol prices.
- There has been a growing social awareness of the potential role of public transport.
- The government has laid down increasingly severe standards for vehicle safety and pollution emissions.
- The rise of car ownership in the sixties was primarily due to the growth in ownership of the first car. But now, with over 80% of households owning a car, the main thrust of future growth must lie in the ownership of second and third vehicles.
- With lower birth and immigration rates the age distribution of the population will change significantly over the next twenty years.

For these reasons we feel it is necessary to consider a model based on causal parameters.

3.2 THE UNIT OF OWNERSHIP

Most models have used cars per capita as the measure of car ownership. While the unit of cars per capita of driver age will allow changes in age distribution to be taken into account, we feel that the household as the unit of ownership is a more economically consistent entity. The need for a car is essentially on a household basis rather than a personal one. The use of the household also allows the differentiation between the ownership of the first and subsequent cars. The lower utility of the second and third vehicles can then be reflected and saturation levels may also be more easily estimated. We suggest that the proportion of car owning and the

proportion of multi-car owning households should be forecast separately.

Changes in the age distribution of the population will be reflected in a continuing decline in average household size (Table 3). The transformation of the proportions of car owning and of multi-car owning households to the total number of cars is not trivial. Vehicles not kept by households and the average number of vehicles in multi-ownership households would need to be estimated. The latter parameter can be reasonably estimated from census or other cross-sectional data. We also suggest that panel vans and light utility vehicles should be included with cars and stationwagons as vehicles for passenger transport.

	Major Urban	Other Urban	Rural	Total
1954	3.44	3.61	3.77	3.55
1961	3.46	3.59	3.78	3.55
1966	3.39	3.49	3.72	3.47
1971	3.26	3.32	3.57	3.31
1976	3.04	3.13	3.37	3.10

TABLE 3

HOUSEHOLD SIZE[1]

3.3 PRIME DETERMINANTS

Income is one of the obvious factors influencing the level of car ownership. The ideal income variable would be some form of permanent income which takes into account present income, past income, wealth, expectations etc. However a satisfactory income parameter is not easy to quantify and real disposable income per household is suggested instead. The growth of household disposable income is closely related to the growth in GDP, the most convenient measure of economic growth. However, in cross-sectional data which may be used for calibration, household income is usually in the form of gross income. A transformation from gross income to disposable income would need to be found.

1. Source: Australian Bureau of Statistics. Population Census 1954-1976

The cost of motoring is another prime determinant of car ownership. This cost parameter will be a weighted index of the real prices of new and used cars, of the other fixed costs of ownership (e.g. registration, insurance and some essential maintenance) and of the variable costs of operating a vehicle. The exact composition of an index is not certain. In particular there is a question whether the variable costs should be partially discounted on the assumption that the marginal car owner is more influenced by the more immediate fixed costs of ownership. The cost index should be adjusted for changes in the size and quality of the average car (see section 5). While no completely satisfactory index has been constructed, the evidence indicates a steady decline of real motoring costs (about 1% p.a.) throughout the sixties and early seventies (e.g. BTE 1975). However recent data (see Table 4) and other forecasts (BTE 1975) indicate that this trend will probably be reversed in future. In the analysis of cross-sectional data the cost parameter cannot be considered.

	Car Prices		Insurance		Petrol Prices	Labour Charges
	Small	Large	Third Party	Compre-hensive		
1960	116.2	124.0	84.9	73.5	109.0	89.4
1965	106.7	106.9	92.1	88.8	99.1	92.5
1970	100.0	100.0	100.0	100.0	100.0	100.0
1973	94.1	94.9	104.0	117.8	97.9	116.4
1976 (end)	98.1	102.0	172.9	150.8	83.5	141.4

TABLE 4

MOVEMENTS IN REAL MOTORING COSTS[1]

1. Sources
Glass's Dealers Guide 1967-1976
Victoria State Insurance. Private Communication
Australian Bureau of Statistics. Review of Business Statistics 1961-1976.
Petroleum Information Bureau. Oil and Australia 1975.

Lifestyles in country areas differ markedly from those in the cities. We may expect that location could be another prime determinant of the pattern of car ownership. Average household size in country areas is larger than that of the urban counterpart but both have been declining over the past fifteen years (Table 3). The greater necessity of owning a car is reflected in the lower proportion of non-car owning households in country areas (Table 5). Projections of the geographical distribution of the population between urban and country areas would be required. It is interesting to note that the 1976 Census indicates that the trend to greater urbanisation has slowed and even reversed (Table 6).

	Proportion of Households with		
	0 Vehicle	1 Vehicle	2 or more Vehicles
Major Urban	23%	51%	26%
Other	15%	51%	34%
Total	20%	51%	29%

TABLE 5

VEHICLE OWNERSHIP IN AUSTRALIA. 1971[1]

	Major Urban	Other Urban	Rural
1954	54%	25%	21%
1961	56%	26%	18%
1966	59%	25%	17%
1971	65%	21%	14%
1976	64%	36%	

TABLE 6

POPULATION DISTRIBUTION IN AUSTRALIA[1]

1. Source : Australian Bureau of Census. Population Census 1954-1976

We think that public transport availability affects the level of car ownership in urban areas. The scarcity of public transport, especially in newly developed areas, will make the ownership of a car a necessity, given the low density pattern of development. Lack of public transport will also encourage the ownership of additional vehicles. The study described in the next section of this paper indicates that these effects are significant and this is a parameter which should not be excluded. The index of public transport availability will probably have to be based on a mainly subjective assessment.

Saturation levels have an obvious influence on future numbers of cars. The precise saturation level of car ownership in terms of cars per capita is uncertain, with estimates set out by Tulpule (1975) ranging from 0.3 to 0.6. The change in the unit of ownership simplifies the problem of estimatation. The saturation proportion of car owning households is certainly between 0.95 and 1.0. The saturation level of multi-ownership is more difficult to determine. Analysis in the next section indicates a level of 0.7. In America of the most affuent 10% of households in 1973, 96.5% owned one or more cars while 69% owned two or more. (USBC 1975) A saturation level of between 0.7 and 0.8 is suggested. However, in terms of forecasting car ownership to the end of this century, the sensitivity of the forecasts to this latter saturation level is likely to be small; from the present proportion of 30% of multi-ownership households there is a long way to go before the first effects of saturation are felt.

Household Structure may also impact significantly on the patterns of car ownership. We would not expect a household of two retired people to own two cars while a family of four or more is clearly a potential owner of a second car. Household structure is also a reflection of the population's age distribution. Golding (1972) suggested the following six categories which he found significant in explaining differences in car ownership.

(i) 0 employed residents; 1 other member
(ii) 0 employed residents; 2+ other members
(iii) 1 employed resident; 0, 1 other members
(iv) 1 employed resident; 2+ other members
(v) 2+ employed residents; 0, 1 other members
(vi) 2+ employed residents; 2+ other members

These, or similar categories, may be suitable. Clearly it may be difficult to construct suitable forecasts of the future numbers of these categories which take good account of age distribution and other social trends. It is suggested that the inclusion of household structure, as a categorical variable, should be a refinement of the proposed model which may be satisfactory without it.

3.4 THE PROPOSED MODEL

We propose the following model structure:

$$F_{ij}(Y,C) = \frac{S_{ij}}{1 + \alpha_{ij} z^{\gamma} e^{-\beta_{ij}(Y/C)}}$$

where F_{ij} is the proportion of households in urban (i = 1)/country (i = 2) areas owning one (j = 1)/two or more (j = 2) cars.

S_{ij} is the saturation level of households in category (ij)

Y is an income parameter (real disposable income per household)

C is a real motoring costs index

z is a measure of public transport availability (in country areas = 1)

and α_{ij}, β_{ij} and γ are constants.

This form of the model presupposes the same elasticity of car ownership with respect to income and cost. While there is no theoretical support for this assumption it is difficult to differentiate between the two on the basis of past data as the movement of the income and cost variables are highly correlated, except for the last two years. Evidence of the last two years may suggest a low cost elasticity. The problems posed by the rapid motoring cost increases of recent years together with rising car ownership are discussed in Section 5. This model also does not contain the effects of any lags in the response to changes in income or cost. However, as the purpose of the model is to estimate the effect of long term trends rather than sharp changes and fluctuations this deficiency may not be serious.

It is, at present, impossible to calibrate this model fully because of data deficiencies. While the Sydney and Geelong Transportation studies do provide some suitable data, only the 1976 Census can possibly provide full country-wide data. However the necessary cross-tabulations may not be easily available.

4. URBAN CAR OWNERSHIP STUDY

A study recently conducted (Hollywood and Cameron 1975) attempted to construct a model for forecasting car ownership in the Sydney area. The data used in the study obtained from the Sydney Area Transportation Study (SATS 1974) was on a cross-sectional basis. The analysis investigated the effect of income and public transport availability on the level of car ownership. Fairhurst (1975) found that the inclusion of public transport availability made a significant contribution to forecasting car ownership in London.

The type of model used in the Sydney study was a modified form of a logistic curve:-

$$F = \frac{S}{1 + K Z^{a} e^{-bY}}$$

Where F is a measure of car ownership.
Z is a measure of public transport availability
Y is a measure of income
s is the saturation level
and K, a & b are constants

Two measures of ownership were considered - cars per person of driver age and cars per household; models were estimated for each of these. For the household ownership model two equations had to be calibrated, one using the proportion of car owning households and the other the proportion of multi-ownership households. The income variable was household disposable income, obtained by applying an approximate transformation to gross income to reflect the effects of taxation. A measure of motoring costs was not included in the model as the data was on a cross-sectional basis; these costs were assumed to be constant over all data points.

An initial analysis in which income was the only exogenous variable was found to be inadequate and so the models were extended to include the effects of public transport availability on the level of car ownership. As there was no readily available measure for the provision of public transport, it was necessary to construct an index to represent this. Two components were used in this index; a subjective assessment was made of how well each area in the study was served by public transport. This was combined with the number of flats as a proportion of dwellings in each area (districts with a high proportion of flats tend to be well served by public transport). This latter component was felt to introduce a degree of objectivity to the public transport measure, although it may have introduced bias in other ways. Fairhurst (1975) used an index combining measures of service frequency and access distance.

The index had a range between 0 - 100 with higher values indicating better service by public transport. Figure 2 shows the data points for car ownership against a base of the income variable; alongside each point the public transport index is noted. It can be seen that for any given value of income the range of car ownership is such that the high values of public transport availability are associated with low values of car ownership, hence illustrating the explanatory power of the index.

Models were constructed for forecasting car ownership both on a household ownership basis and also in terms of cars per person of driver age. In the estimation procedure use was made of non-linear regression methods to calibrate the models. This was found to be quite successful although some difficulty was experienced due to the estimates being quite sensitive to initial parameter values which had to be supplied to the program. The results are shown in Table 7. In comparing the results of

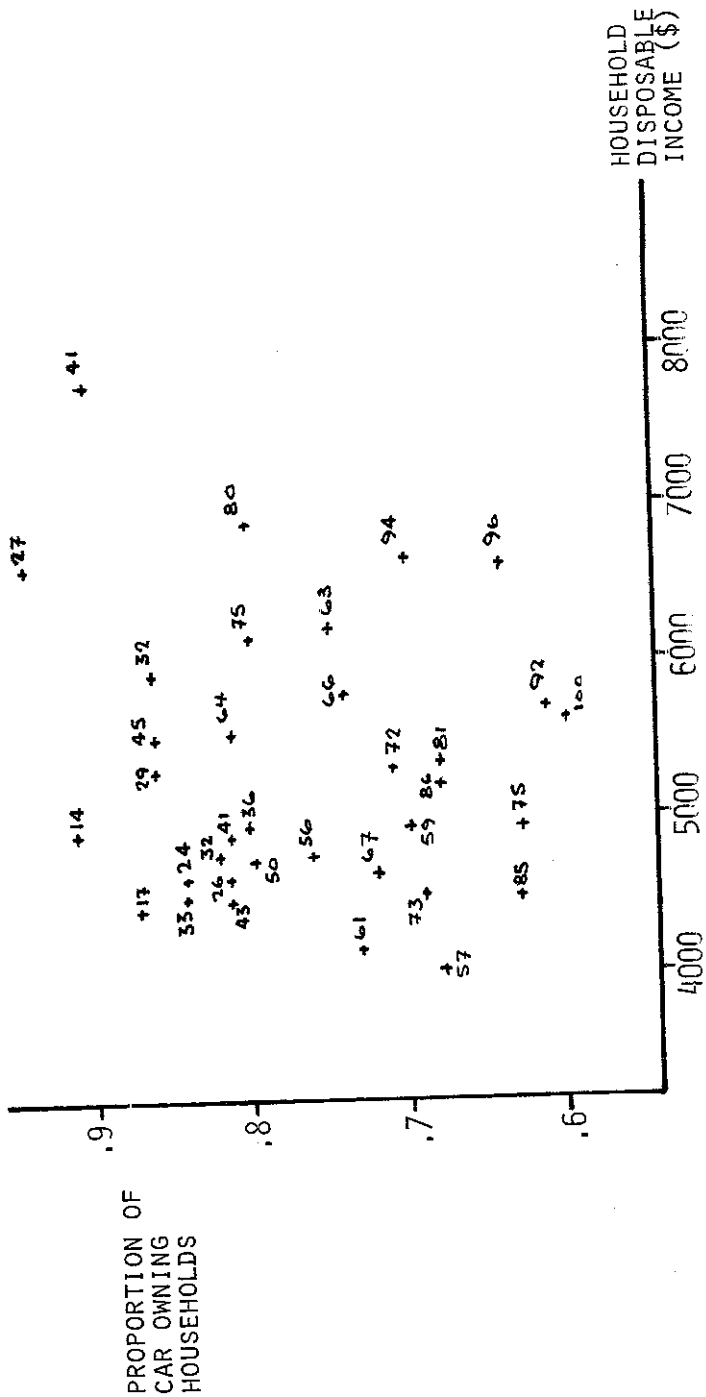

FIGURE 2. EFFECT OF INCOME AND PUBLIC TRANSPORT AVAILABILITY ON CAR OWNERSHIP

the two models it was felt that the model using the household as the unit of ownership gave the better results. This comparison however was difficult to carry out statistically as the driver age model used only one estimation equation and the cars per household model used two. Also it would be necessary to convert both measures to a comparable value and some error would be introduced in the conversion.

Dependent Variable	S	K	a	b
Cars per person of driver age	1.00	.472	.366	.341
Proportion of households owning one or more cars	0.95	.00304	.419	.224
Proportion of households owning two or more cars	0.70	.567	.729	.286

TABLE 7

CALIBRATIONS OF URBAN CAR OWNERSHIP MODELS ON SYDNEY 1971 DATA

The analysis attempted to determine how sensitive the forecast results were to the saturation levels used in the models. By carrying out the estimating procedures using a range of saturation levels, it was found that the forecast results did not appear to be sensitive to changes of about $\pm$ 10% of the base value. Saturation levels were also estimated directly from the data; this was possible because using non-linear regression methods the saturation level can be input as a parameter to be estimated. The values shown in Table 7 were considered reasonable although some difficulty was encountered in their estimation due to local minima.

5. A FUTURE DECLINE IN THE GROWTH OF CAR OWNERSHIP?

In the period up to 1973 real per capita disposable income rose by an average 3% p.a. In the same period real motoring costs declined by 1% p.a. (see Table 4). Thus the index of income relative to motoring costs was rising at a rate of about 4% p.a. While a slight decline in the rate of growth of disposable income in the future may be anticipated, the sharp reversal in trend of motoring costs has already been seen. If these trends continue (BTE 1975) the movement of the index will slow to a rate of 1½% to 2% p.a. As a result forecasts based on the use of this index will show a sharp decline in the rate of growth of car ownership. This will be

reinforced by the approaching saturation of first vehicle ownership, although partially offset by declining household size and a slow down in the rate of urbanisation. The results of the two models which take into account income and costs (section 2) indicate a level of only 0.42 cars per capita by 1990 on these assumptions, while on the basis of a continuation of past trends a 1990 level of 0.47 cars per capita is indicated (Table 2 and Figure 1).

It maybe considered likely that the effects of the sharp increases in car prices and other costs (especially insurance) over the last two years should have been reflected in the levels of car ownership. However, car ownership has continued to rise steadily from 0.34 cars per capita at the end of 1973 to 0.375 three years later. This would seem to be inconsistent with a significant, negative cost elasticity. A growth in ownership from 0.375 to 0.42 cars/capita over the next thirteen years, together with reasonable assumptions on scrappage rates and of a population growth of 1.8% p.a., results in an average increase in new registrations of only 3.7% p.a. (cf 6.4% p.a. for 1960 to 1975).

It should be remembered that we are considering an essentially long term trend model and any lagged effects are ignored. It is possible, though unlikely, that the recent growth in car ownership is the result of the rapid income increase in 1972 and 1973 (where real disposable income per capita rose 13% in two years) and that the dampening effects of the cost rises have yet to be felt. Another possible reason is that the growth in unemployment has caused a significant change in the distribution of income; thus the growth in the average household income has understated the increase in affluence of the (employed) car owning group. Another reason can be found in the closer analysis of new car sales.

In Table 8 the growth of the market share of the smaller car (four cylinder and small six cylinder) can clearly be seen. While the actual supply of these vehicles (which is partly determined by world-wide trends) may be one of the causes of the popularity of these cars, the demand for smaller cars is also in response to higher prices, awareness of increasing oil costs and pollution and the growth of the second car. In any case the average cost of owning and operating the average car has not risen as fast as the cost of owning and operating any particular car. The trend to

smaller cars (and thus to lower costs and prices) has partly outweighed the sharp increase in prices.

	Percentage of New Cars and Stationwagons		
	≤ 17 HP	18-27 HP	≥ 28 HP
1971	32%	17%	51%
1972	30%	14%	56%
1973	34%	12%	52%
1974	36%	14%	50%
1975	40%	15%	45%
1976 (1st Half)	41%	15%	44%

TABLE 8

SIZE MIX OF NEW CARS AND STATIONWAGONS[1]

We therefore need a size/quality adjusted index of motoring costs. (We should also take into account the countervailing movement to higher quality cars in terms of automatic transmission, air-conditioning etc.) The size/quality of the average car will be determined by the mix of cars in the total fleet rather than the mix of new cars. Table 9 shows the approximate effect of a size-adjusted index. The switch to small cars clearly has a significant effect in counter-balancing the increase in motoring costs.

Cost of owning a large car relative to a small car	1.4
Cost Index with 33% small cars (1973 position)	100.0
Cost Index with 55% small cars (possible position in 1983)	93.1

TABLE 9

THE EFFECT OF A SIZE-ADJUSTED INDEX

1. Source: Australia Bureau of Statistics: Motor Vehicle Registrations 1971-1976.

While a rational explanation may have been found for the apparent paradox of a high rate of growth of car ownership in the face of increasing real costs, we are still left with the problem of forecasting the future size/ quality mix of new cars. Conventional economic theory leads us to expect that a real price rise of cars and an increase in the price of large cars relative to smaller cars will result in a swing away from large vehicles. The only attempt to quantify such an effect is the IAC model (IAC 1974). This uses a linear equation with a supply variable (to reflect the introduction of the small six cylinder car) and the ratio of comparative costs of large and small cars as the independent variables. Unfortunately the supply variable dominates the determination of the dependent variable (market share of smaller cars). The lack of sensitivity of the cost ratio variable is shown in Table 10. While such a result may be satisfactory for short to medium term forecasts, it does not appear a valid assumption for the longer term.

	Motoring Costs -2% pa	Motoring Costs +1% pa	Motoring Costs -2% pa	and 50% higher petrol prices
1980 Market Share of Small Cars	55.44%	55.65%	55.77%	

TABLE 10

SENSITIVITY OF IAC MODEL

Another problem is that in the search for a behaviourally valid model we must ask what group of the population determines the size mix of new cars (and thus of the whole fleet). One third of new car sales are company and fleet purchases. These, for various practical reasons, are likely to remain predominantly in the large car sector. As for the remaining two thirds of sales to the personal sector, the purchaser of a new car is rarely the marginal car owner. The marginal first or second car owner is most likely the purchaser of a used car and thus has only very indirect, and minor, effect on the new car size mix. In this respect we may find the new car mix less sensitive to the cost ratio than we might at first expect.

A definitive solution of this problem is not proposed. The effect of the substitution of large cars by small vehicles is a lower elasticity of car ownership with respect to cost. It may then be necessary to adopt a different form of the car ownership equations to allow different income and cost elasticities:-

$$F_{ij}(Y,C) = \frac{S_{ij}}{1 + \alpha_{ij} z^{\gamma} e^{-\beta_{ij} Y + \delta_{ij} C}}$$

where α_{ij}, β_{ij}, δ_{ij} and γ are positive constants.

6. CONCLUSIONS

In this paper we have argued for a car ownership forecasting model based on causal parameters. The retention of the use of simple extrapolation techniques for long term forecasts does not appear justifiable despite their ease of use. We have suggested that the household is the most economically consistent unit of ownership. Consideration of ownership on a household basis allows the differentiation between the first and subsequent vehicles and their respective saturation levels. In addition to income and cost variables, location, public transport availability and, perhaps, household structure, are variables which should be included. We have shown that the public transport variable is most important in determining urban car ownership. There are still some unresolved difficulties associated with the measurement of public transport availability and with the effect of smaller cars.

The 1976 national census provides a source of country-wide data which, for the first time, enables the calibration of such a model to be carried out. It would be necessary that the data would enable the identification of numbers of households into categories of location (local government area), income, car ownership and household structure. The opportunity to construct this model should not be lost, especially in the light of Australia's energy budget.

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