Model for Forecasting Vehicle Ownership in New Zealand

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Contents

Executive Summary

Introduction

The two principal objectives of the Vehicle-Ownership Forecasting Model research project, undertaken in 1996-1997, are to provide:

1. A model or basis for forecasting vehicle-ownership trends at national and regional levels in New Zealand over the next 20 years (2000-2020);
2. A set of preliminary forecasts of future vehicle-ownership levels, based on these models.

Three different types of vehicle-ownership models (macro-economic, micro-economic, cohort processing models) have been examined:

- Macro-economic models, which generally perform well in the short to medium term (although they have several important limitations);
- Micro-economic models, which do not perform credibly over time; and
- Cohort processing models, which require data about individual vehicle ownership and income level that are not available in New Zealand.

The most effective approach for estimating vehicle ownership at a national level is a macro-economic model.

Data on the long-term trends in vehicle ownership in New Zealand over the last 25 years showed that:

- Over the period since 1970, regression analyses indicate that annual changes in car ownership (per person) are well "explained" by changes in GDP per person and car prices, plus a diminishing annual "time trend".
- The elasticity of annual changes in cars per person with respect to changes in GDP per person is estimated at 0.43, and with respect to changes in car prices is estimated at -0.17. These elasticities occur with little lag and should be regarded as "short run" estimates.

The apparent "unexplained" time trend reduced rapidly over the period by an average of 0.13% pa, to reach about 0.6% by 1996. This is relatively faster than the rate of reduction before 1970, which was about 0.08% pa over the period 1958 - 1970. This change may indicate an approach to saturation, although this is far from certain on the evidence available.

Basis for Forecasting Vehicle Ownership

Two critical elements in providing realistic vehicle-ownership forecasts are:

- Appropriate saturation level,
- Growth path to saturation.

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- Appropriate saturation level,
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Determining the level of saturation

Plausible maximum and minimum values for saturation levels that have been derived are:

- Maximum: 0.95 "effective" vehicles/person of driving age.
- Minimum: 0.85 "effective" vehicles/person of driving age.

The current saturation levels are in the range 0.66 vehicles/person (minimum) to 0.74 vehicles/person (maximum). By year 2031 these increase, because of changes in age distribution, to 0.70 vehicles/person (minimum) and 0.78 vehicles/person (maximum).

Determining the growth path to saturation

The second critical element in forecasting future vehicle-ownership levels is the growth path taken to reach the saturation level. The time scale taken will be influenced by:

- General level of economic activity (GDP/person),
- Real cost of motoring (both car purchase and car use),
- Household structure,
- Relative accessibility of private- and public-transport consumer taste.

A reducing time trend was observed, in which the effects from the trend of changes in GDP and car prices have become relatively more significant. This evidence would suggest, in terms of future growth projections, that:

- The underlying time trend in future may be much lower than historic trends, probably less than 1% and maybe close to zero.
- Economic factors are likely to have proportionally larger effects on the future growth pattern.

National Vehicle-Ownership Forecasts

The approach just described has been applied to develop a series of national forecasts of vehicle ownership per person on the following basis:

- Starting from the 1996 estimate of vehicles/person, obtained from the Motor Registration Centre (MRC) figures as adjusted (i.e. 0.493 cars/head).
- Application of "low", "medium" and "high" growth projections based on the regression analyses that have been undertaken, and plausible ranges for trends in GDP/person, car prices, and annual time trends.
- Constraint of the "minimum" and "maximum" saturation levels.

Regional Vehicle-Ownership Forecasts

The approach suggested for deriving regional forecasts of vehicle ownership, that are consistent with the national forecasts, is as follows:

- Adjust the region's latest (1996) Census data on vehicles/person by the national adjustment factor from the Census statistics to MRC (adjusted) statistics to provide an estimate of the region's vehicles/person consistent with the national MRC data.
- Locate the region's vehicles/person on a graph, and assume that the growth rate for the region follows the national projections, albeit displaced by a few years (according to the region's vehicle ownership relative to the national average figure).

Potential Areas For Further Research

Several issues have arisen in the project which have not been able to be fully addressed and resolved at this stage, but would warrant further work in order to provide improved national and regional forecasts with greater confidence.

These include:

- Relationship between 1996 Census data and MRC data.
- International evidence on factors influencing vehicle ownership, in the light of New Zealand findings reported here. In particular, this should examine the most recent research relating to:
  - Saturation levels,
  - Use of cohort processing models and licence-holding data as the means of determining levels of saturation and the approach to use,
  - Influence of economic variables on vehicle-ownership trends.

Abstract

The Vehicle-Ownership Forecasting Model research project, undertaken in 1996-1997, is described. The two principal objectives of the research are to provide:

1. A model or basis for forecasting vehicle-ownership trends at national and regional levels in New Zealand over the next 20 years (2000-2020);
2. A set of preliminary forecasts of future vehicle-ownership levels, based on these models.

The basis for forecasting vehicle ownership, by determining both the level of saturation and the growth path to saturation, is explained, then applied to develop a series of national forecasts of vehicle ownership per person. An approach for deriving regional forecasts that are consistent with the national forecasts is also described.

1. Introduction

1.1 This Project

The Vehicle-Ownership Forecasting Model research project that was undertaken for Transit New Zealand (Transit) by Booz·Allen & Hamilton, in 1996-97, has two principal objectives:

1. To provide a model or basis for forecasting vehicle-ownership trends at national and regional levels in New Zealand over the next 20 years (2000-2020);

2. To provide a set of preliminary forecasts of future vehicle-ownership levels, based on these models.

The work has been divided into six principal research tasks:

1. Literature review of vehicle-ownership forecasting models,
2. Investigation of data availability,
3. Outline of proposed model structure,
4. Interim report and review workshop,
5. Detailed model development,
6. Recommendations and reporting.

1.2 This Report

This report is structured as follows:

Chapter 2 presents the results of the review of international literature of trends in and influences on vehicle ownership.

Chapter 3 contains our international review and appraisal of alternative potential approaches to modelling vehicle ownership.

Chapter 4 reports on our work relating to vehicle ownership in New Zealand. This covers past trends and causal factors, and issues of data availability for forecasting purposes.

Chapter 5 outlines our proposed modelling approach and summarises further work to be undertaken in the project.

The Appendices (listed on the contents page) provide more detailed coverage of specific issues.

2. Past Trends & Influences on Vehicle Ownership: Literature Review

2.1 Introduction

An international review of trends in vehicle ownership and the main influences on these trends, for New Zealand and for comparable countries, was carried out. This review covers three main issues:

1. the shape of the vehicle ownership curve over time,
2. the major influences on vehicle ownership,
3. the saturation level of vehicle ownership.

2.2 The Shape of the Vehicle Ownership Curve

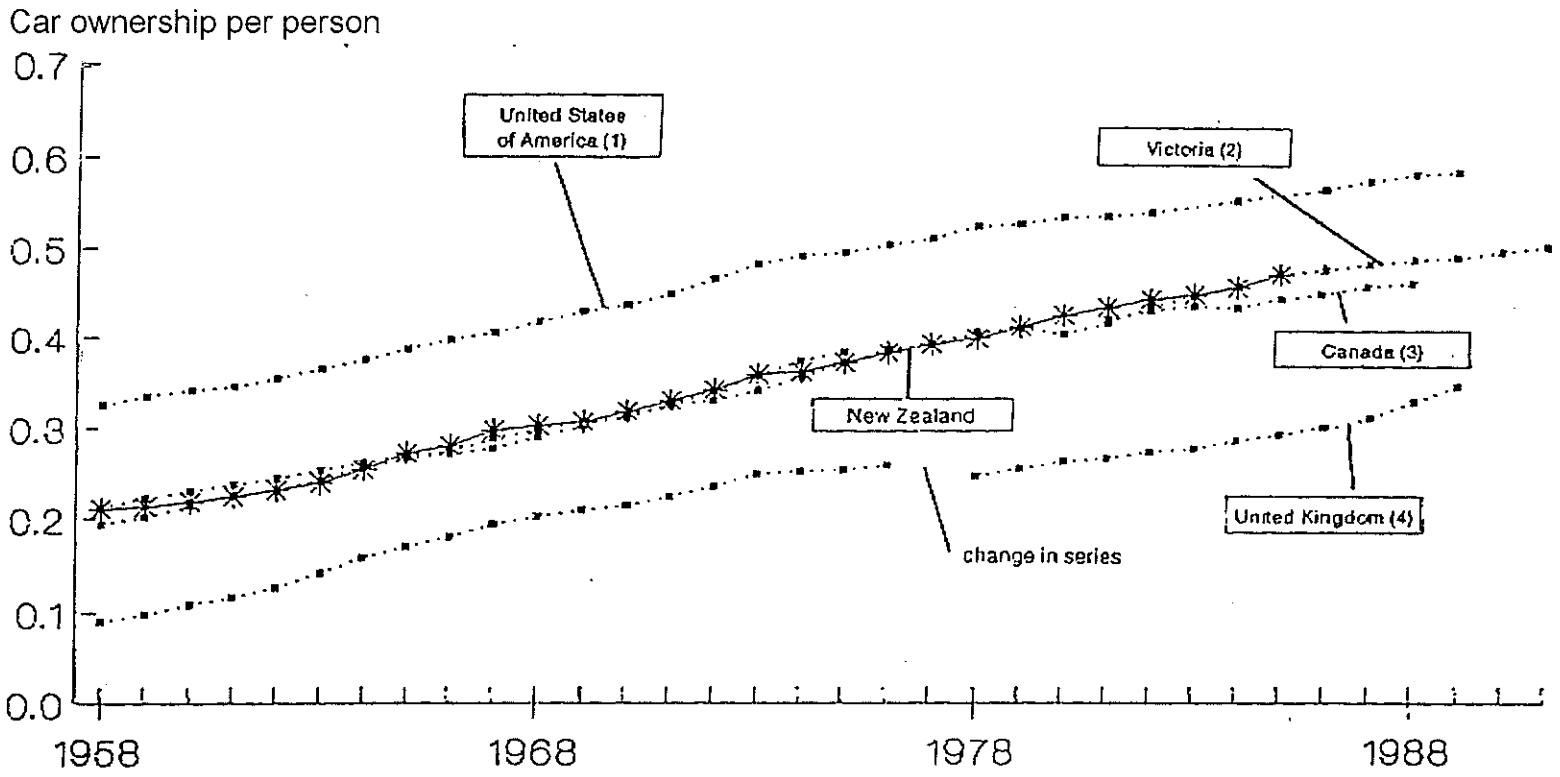
Figure 2.1 shows the growth in vehicle ownership per person over the last 30 years for the major English-speaking countries. Canada and Victoria (a typical Australian state) are included as they are culturally and economically similar to New Zealand. The United States (US) and the United Kingdom (UK) are included because of their different economic circumstances.

The level of vehicle ownership in New Zealand is approximately half-way between that of the UK and the US, and is similar to that in Canada and Victoria. Vehicle ownership per person has grown steadily over the period for all the countries shown, although there have been short-term fluctuations in response to changes in economic conditions.

Figures 2.2 and 2.3 show the annual growth rates of vehicle ownership per person and income (both averaged over 3 years) for Victoria and the US. The general trend for the rate of growth of ownership is to decrease as vehicle-ownership levels increase. While a clear correlation exists between income growth rates and vehicle ownership growth rates generally (certainly in the US), the growth in vehicle ownership is less fluctuating than the growth in income.

Figure 2.4 shows the growth in per person-vehicle ownership for a selection of US states for the period 1970-1989. Per person-vehicle ownership for all states is tabulated in Appendix B in this report. The US data demonstrate that 14 of the 52 states had per person-vehicle ownership greater than 0.60 in 1986. Of four examples in this category (in Figure 2.4), the level of per person-vehicle ownership and the ratio of vehicles to driving licences were: 0.620 - 0.832 vehicles per person, and 0.88 - 1.13 vehicles per licence respectively, as shown in Table 2.1.

Figure 2.1 **Trends in car ownership per person.**



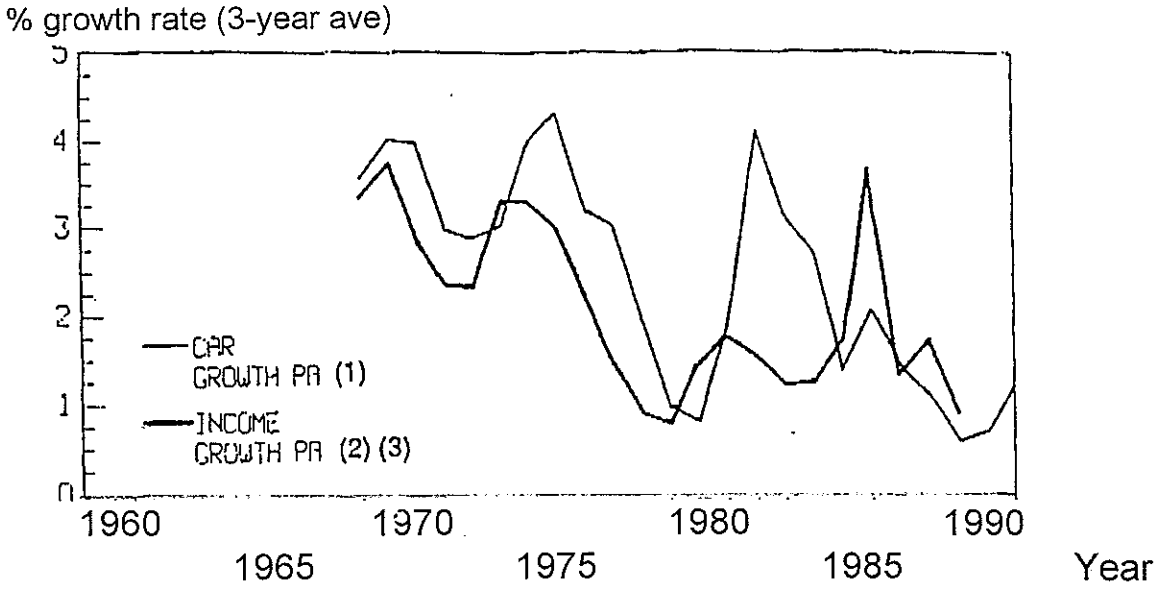
Notes: (1) US data after 1986 based on US Federal Highway Administration, **Highway Statistics (Annual)**, and **Selected Highway Statistics and Charts (Annual)** in **Statistical Abstract of the United States**, 1990, p.23, and 1991, pp.23 and 609; and **Transport Statistics Great Britain**, 1989, p.195.

(2) Victoria data between 1987 and 1991 based on Australian Bureau of Statistics, **Motor Vehicle Registration Australia 1990-91** (Catalogue No. 9304.0), Canberra, Commonwealth Government Printer, 1992, p.20.

(3) Canada data between 1986 and 1988 based on Statistics Canada, **Canada Year Book 1990**, November 1989, pp.2-21, 13-19, and Hunter, B., **The Stateman's Year Book 1991-92**, 128th edition, The Macmillian Press Ltd, 1991, p.291.

(4) UK data (incl. taxis) between 1987 and 1989 based on various editions of **Transport Statistics Great Britain**.

Figure 2.2 Annual car ownership and income growth rates for Victoria, Australia.

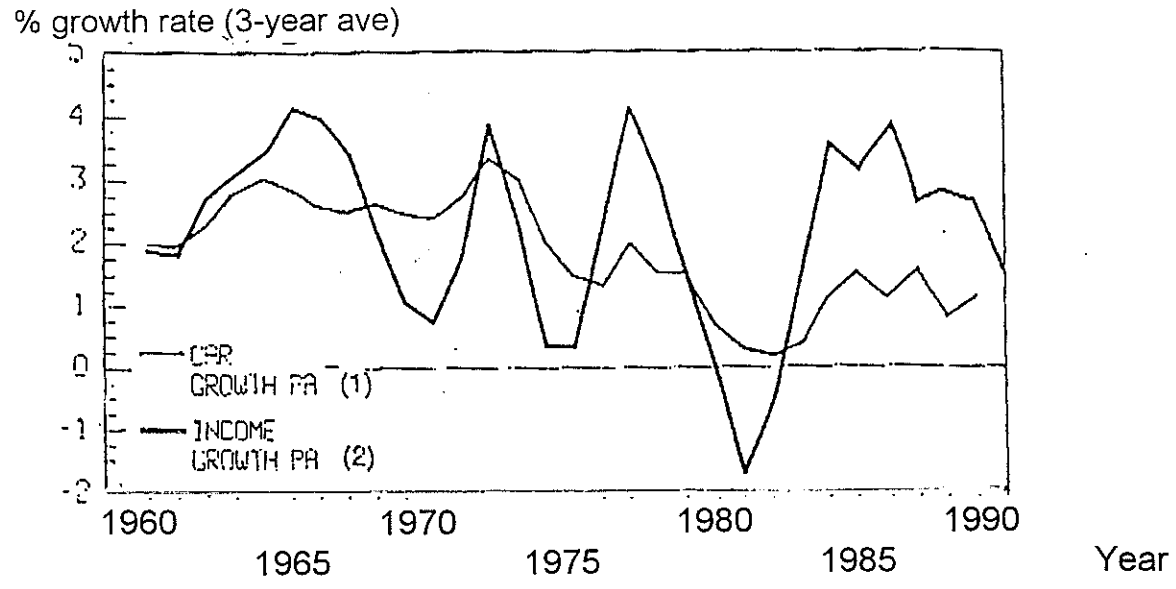


Notes:(1) Victoria data based on Australian Bureau of Statistics, **Motor Vehicle Registrations Australia 1990-91** (Catalogue No. 9304.0), Canberra, Commonwealth Government Printer, 1992, p.20; and ABS, **Motor Vehicle Registration Australia 1985-86** (Catalogue No. 9304-0), Canberra, Commonwealth Government Printer, 1987, p.17.

(2) Australian Bureau of Statistics, **Australian National Accounts: State Accounts 1988-89** (Catalogue No. 5220.0), Canberra, Commonwealth Government Printer, 1990, p.5, Summary Table No.2; Gross Domestic Product at market prices per head of mean population.

(3) Australian Bureau of Statistics, **Australian National Accounts: National Income & Expenditure Summary 1988-89** (Catalogue No. 5201.0), Canberra, Commonwealth Government Printer, 1990, p.6.

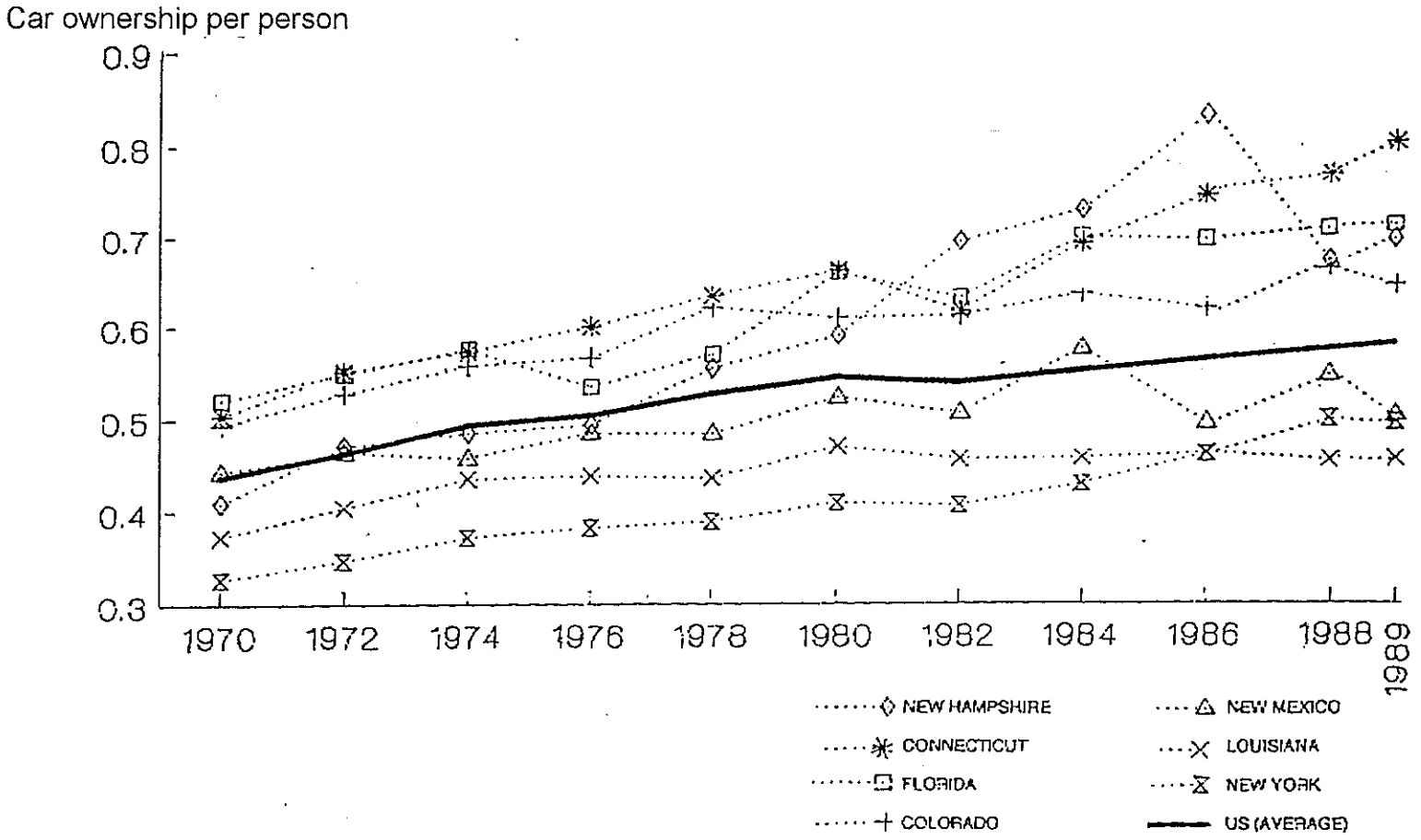
Figure 2.3 Annual car ownership and income growth rates for the US.



Notes: (1) US car growth data after 1986 based on US Federal Highway Administration, **Highway Statistics (Annual)**, and **Selected Highway Statistics and Charts (Annual)** in **Statistical Abstract of the United States**, 1990, p.23, and 1991, pp.23 and 609; and **Transport Statistics Great Britain**, 1989, p.195.

(2) US income growth data after 2986 based on Table 20: Gross Domestic Product per head - at the price levels and exchange rates of 1985 (US$) in OECD, **National Accounts Volume 1: Main Aggregates 1960-1990**, Paris, 1992, pp.130-131.

Figure 2.4 **Car ownership per person for selected states of the US, for 1970-89.**



Notes:

(1) US data before 1986 based on US Federal Highway Administration, **Highway Statistics**.

(2) US data for 1988 based on US Federal Highway Administration, **Highway Statistics (Annual)** and **Selected Highway Statistics and Charts (Annual)** in **Statistical Abstract of the United States**, 1990, p.603.

(3) US data for 1989 based on US Federal Highway Administration, **Highway Statistics (Annual)** and **Selected Highway Statistics and Charts (Annual)** in **Statistical Abstract of the United States**, 1990, p.609; and US Bureau of the Census, **Current Population Reports**, Series P-25, No. 1058 in **Statistical Abstract of the United States**, 1991, p.23.

Table 2.1 Level of vehicle ownership per person for four US states.

US State	Vehicle Ownership per Person	Vehicles per Licence
Colorado	0.620	0.88
Florida	0.697	1.01
Connecticut	0.745	1.02
New Hampshire	0.832	1.13

Despite the very high levels of vehicle ownership in these four states, there is little evidence of any pronounced slowing down in the growth rates, which might be expected if vehicle ownership were to exhibit the S-shaped growth path which is typical of major consumer durables such as refrigerators and televisions (see Cramer (1962); Bain (1962)).

Wadhwa (1981) and other researchers have both fitted a variety of vehicle-ownership models to Australian data. The models fitted were linear, and were various logistic curves which used time, income, and income deflated by motoring costs as the explanatory variables. All models fitted the data well, with the linear model having the smallest coefficient of variation. While these results were based on Australian data, similar results would have been obtained by applying the models to the countries (US, UK, Canada, NZ) shown in Figure 2.1.

In summary, the growth in per person-vehicle ownership in recent years for the major English-speaking countries can be successfully modelled by a variety of approaches. In Australia, a simple linear model fitted the data better than any other model. However, commonsense dictated that the ownership curve must level off as saturation is approached. Major consumer durables such as refrigerators and televisions follow S-shaped ownership curves, and vehicles would be expected to follow a similar curve.

Levels of vehicle ownership in the major English-speaking countries currently lie in the middle of the S-shaped curve. To date, the turning point has not been successfully identified by statistical analysis and, even when any such turning point occurs, it is difficult to statistically distinguish the turning point from the short-term fluctuations.

2.3 Major Influences on Vehicle Ownership

The major influences on the level of vehicle ownership are:

- general level of economic activity,
- real cost of motoring,
- public transport availability,
- household structure,
- consumer taste.

Some other factors that, a priori, might be considered to influence vehicle ownership are often found not to have any significant effects. The main reason for this is that these factors are mostly correlated to the general level of economic activity. For this reason the appraisal focuses on the above five influences, which are easily measured and forecast.

2.3.1 General Level of Economic Activity

It is virtually unchallenged that the rate of growth of vehicle ownership is related to the general level of economic activity.

Figure 2.1 shows the annual growth rates of per person-vehicle ownership and income for New Zealand, the US, and Victoria (Australia). Fluctuations in the rate of economic activity generally (with some exceptions) coincide with similar fluctuations in the rate of vehicle-ownership growth throughout the period shown. For example, the upsurge in the world economy in the mid-1980s had a noticeable effect on the rate of growth of vehicle ownership, particularly in New Zealand and the US.

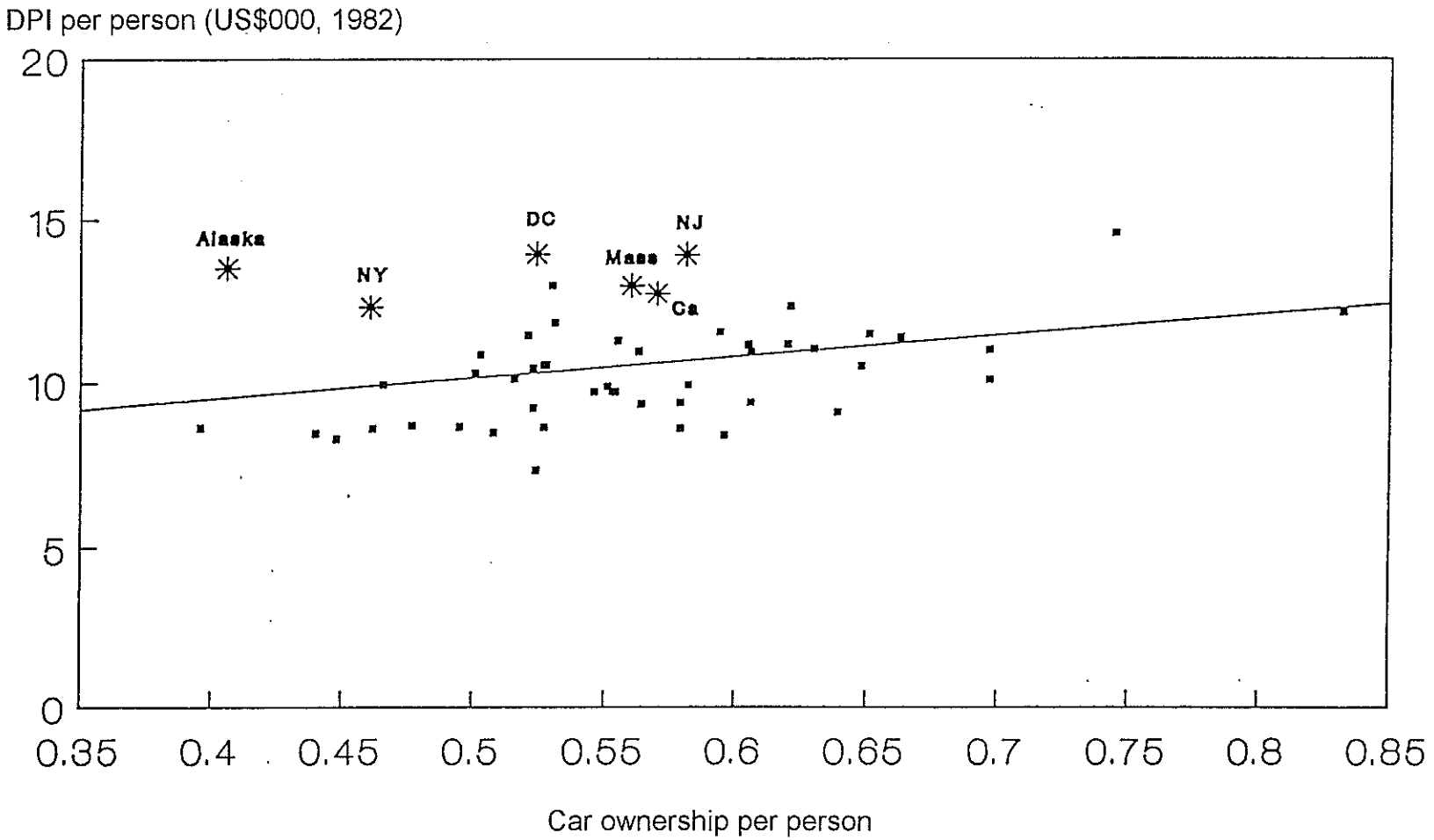
However, the relationship is not straightforward and vehicle ownership often continues to grow even during periods of economic stagnation, e.g. Victoria in the early 1980s, and New Zealand in the mid to late 1970s and late 1980s. While this, to some extent, can be explained through changed saving and consumption patterns (vehicle purchase may be financed through borrowing or saving), it also indicates that growth in vehicle ownership is influenced by factors other than the level of economic activity.

An aggregate statistic such as GDP per person is an incomplete measure of the level of economic activity and the distribution of income can also play an important role. This is discussed in Appendix C of this report, in the context of New Zealand in the mid to late 1970s.

In Figure 2.5, per person-vehicle ownership in 1986 has been plotted against disposable personal income per person for the US. The influence of increasing income on the level of vehicle ownership is shown by the trend line. In general, US states with levels of per person-vehicle ownership exceeding 0.60 have relatively higher disposable personal incomes per person. As expected, the major urban conurbations lie in the top left quadrant of the diagram. These areas are characterised by vehicle ownership levels which are significantly below those in smaller cities and suburbs (with comparable income). Much of this difference is related to the physical constraints on vehicle ownership and use, particularly congestion and parking problems, as well as the availability of public transport.

This relationship between vehicle ownership and income is further emphasised by measured elasticity of vehicle ownership with respect to income. This elasticity tends to decline over time and is higher among lower income groups than higher income groups. These differences reflect the expected pattern as saturation levels are approached.

Figure 2.5 **Car ownership versus disposable personal income (DPI) for the US, in 1986.**



Source: US Federal Highway Administration **Highway Statistics**. Data subject to revision.

NY New York; DC District of Columbia; Mass Massachusetts; Ca California; NJ New Jersey

2.3.2 Real Cost of Motoring

The level of vehicle ownership will generally increase with a decrease in the real cost of motoring. The elements comprising the real cost of motoring include the real prices of new and used vehicles, the other fixed costs of ownership (e.g. registration, insurance, and some essential maintenance), and the variable costs of owning a vehicle. The evidence given by Wadhwa (1981) for Australia is that motoring costs have represented a fairly constant proportion (9-10%) of disposable income. The major influences on the future real cost of motoring in New Zealand are likely to be the exchange rate and the price of fuel.

2.3.3 Public Transport Availability

Scarcity of public transport, especially in newly developed areas, makes the ownership of a car more necessary. There is general agreement that the level of public transport provision has little impact on first car ownership but rather more on second and third car ownership. The impact is localised and overall the impact is small, probably 0.05 vehicles per person at most, or 10-20% of current ownership levels, based on UK, European and Australian analyses. This effect is discussed further in Appendix A of this report.

2.3.4 Household Structure

Household structure may also impact significantly on the patterns of vehicle ownership. A non-family household of two adults would be more likely to own more vehicles than would a household of two retired people. Household structures are a reflection of social trends such as changing age distribution of the population and the tendency to lower household sizes. This tendency is, on its own, likely to result in higher vehicle ownership than would otherwise occur with constant household sizes.

2.3.5 Consumer Taste

While the private car was originally perceived as an extreme luxury, it is now perceived as a necessity by most people. The associated increase in vehicle ownership cannot fully be explained through the variables discussed above. Much recent research into vehicle-ownership forecasting appears to focus on this aspect.

The official UK National Road Traffic Forecasts (DoT 1984, 1989) use a time trend as a proxy for the influence of taste and other unidentified factors on the level of vehicle ownership. These factors reflect changing perceptions and expectations from generation to generation about the need for, or difficulty in, owning or using a vehicle. Many earlier vehicle-ownership models completely focused on this factor, using time as the sole independent variable.

Historically income and time have been highly correlated. The use of a time trend factor is desirable to help explain historical vehicle-ownership data over periods of economic stagnation or decline. However, it is dangerous to conclude that vehicle ownership would continue to increase at past rates, or at all, over extended periods of economic decline.

While vehicle-ownership levels in different countries are generally quite well correlated with the relative income levels of those countries, there are many variations from this general trend. For instance, New Zealand has an exceptionally high vehicle-ownership level relative to its income level. This may partly be explained by patterns of development, but consumer taste also undoubtedly plays a part.

A more thorough understanding of the reasons underlying these changes in taste may be found from panel data approaches, such as those used by Hensher (1986) and Goodwin (1986), which involve monitoring a sample of households over several years to establish a longitudinal data set. Even this, however, can only give limited insight as to what people's behaviour would have been in the environment of, say, thirty years ago (1960s).

In another study using panel data, Golob (1989) found that the relationship between income and vehicle ownership was not stationary over time. There is thus ample evidence of strong underlying factors in addition to income that explain the historical increases in vehicle ownership.

2.4 The Saturation Level of Vehicle Ownership

The saturation level of vehicle ownership per person is uncertain. Data from the four US states with the highest per person-vehicle ownership levels in 1986 are inconclusive. As noted earlier, even in these states there is little sign of any pronounced slowing down in the vehicle ownership–growth rate. New Hampshire, with the highest ownership rate of 0.832 vehicles per person (1.13 vehicles per licence held), shows little sign of a slow-down in growth.

In view of the inconclusive evidence from current data, the saturation level must be estimated by other means. Two approaches are normally adopted:

1. Use of statistical techniques on existing data to extrapolate a growth path. The saturation level is taken where this growth path levels off.

2. Examination of the behaviour of the vehicle-owning population that has a relatively high income. Saturation levels estimated for this population are assumed to flow through to the remaining population of vehicle owners as their real income levels increase over time.

The first of these approaches to forecasting a saturation level involves fitting a regression line to the annual growth rates of per person-vehicle ownership, and extrapolating this line to the x axis. This is the approach adopted by Groenhoet & Bell (1985) for vehicle ownership in Sydney, and by Bates et al. (1978) in forecasting vehicle ownership in the UK. This approach will generally perform reasonably well over the short to medium term. However, the approach fails to address the effect of economic influences (i.e. income, real cost of motoring) on the growth path.

The development of a saturation level is a long-term effect and there is considerable uncertainty that the modelled relationship will continue to hold in the long term, even when economic influences are included in the model.

The second approach to forecasting vehicle ownership looks at the behaviour of the vehicle-owning population with relatively high incomes. Figure 2.6 shows a plot of vehicle ownership per adult against income per adult based on the 1977-78 US National Transportation Personnel Study (NTPS), as reported by Tanner (1981). The data shows a levelling off at around 0.95 vehicles per adult at relatively high income levels. This saturation level is assumed to be applicable to the remaining population as their real income levels increase over time.

US licence data reinforces this conclusion, suggesting an upper limit of around 95% of adults who will ultimately hold a licence to drive. Although the overall licence-holding level for women in 1978 was only 73%, compared with 89% for men, the difference for young adults (up to the age of 39) was only 8 percentage points. This small difference between the sexes seems likely to work its way through to higher age ranges as the individuals grow older.

The ratio of vehicles to driving licences for the three US states with the highest levels of vehicle ownership in 1986 ranged from 1.01 (Florida) to 1.13 (New Hampshire) (Table 2.1). In situations like these, where this ratio approaches or exceeds one, there is a case for distinguishing between cars per adult and adults with car available. For the purpose of traffic forecasting the latter would appear more appropriate since only one car can be driven at a time.

In the UK and Australia, average income levels are considerably lower than in the US and therefore data from these countries are of little assistance in assessing the saturation level. Figure 2.7 shows the 1978-79 Great Britain National Travel Survey (NTS) data reported by Tanner (1981). These data show the same general trend as the US data for lower levels of income (Figure 2.6).

The UK National Road Traffic Forecasts (NRTF) (DoT 1989) assumed a saturation level based on vehicles being owned by 90% of the driving age group, which was defined to be aged 17 to 74 years. An assumption like this is likely to be influenced by current perceptions about vehicle ownership and needs to be used with caution.

The saturation level of per person-vehicle ownership will be influenced by the following factors:

- Proportion of the population who are permitted by law to drive a car,
- Proportion of the potential car-owning population unable to drive because of physical or mental disability,
- Proportion of the potential car-owning population who choose not to own a car.

Figure 2.6 Cars per adult and income per adult, from US National Transportation Personnel Study (NTPS) of 1977-78.

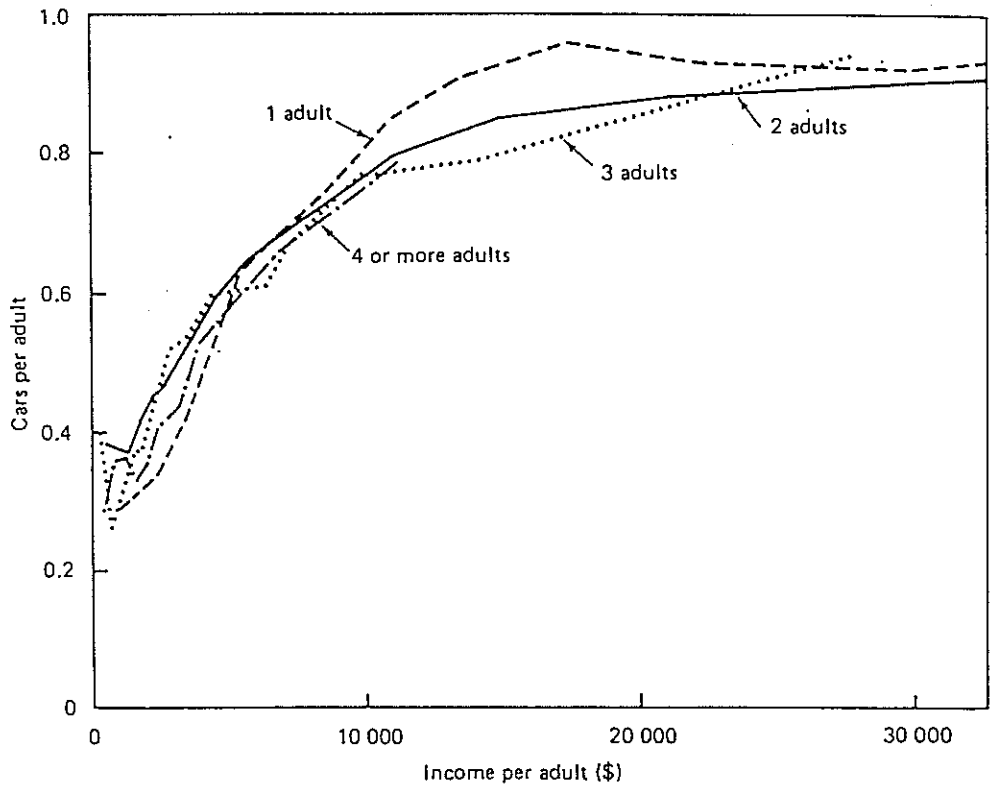
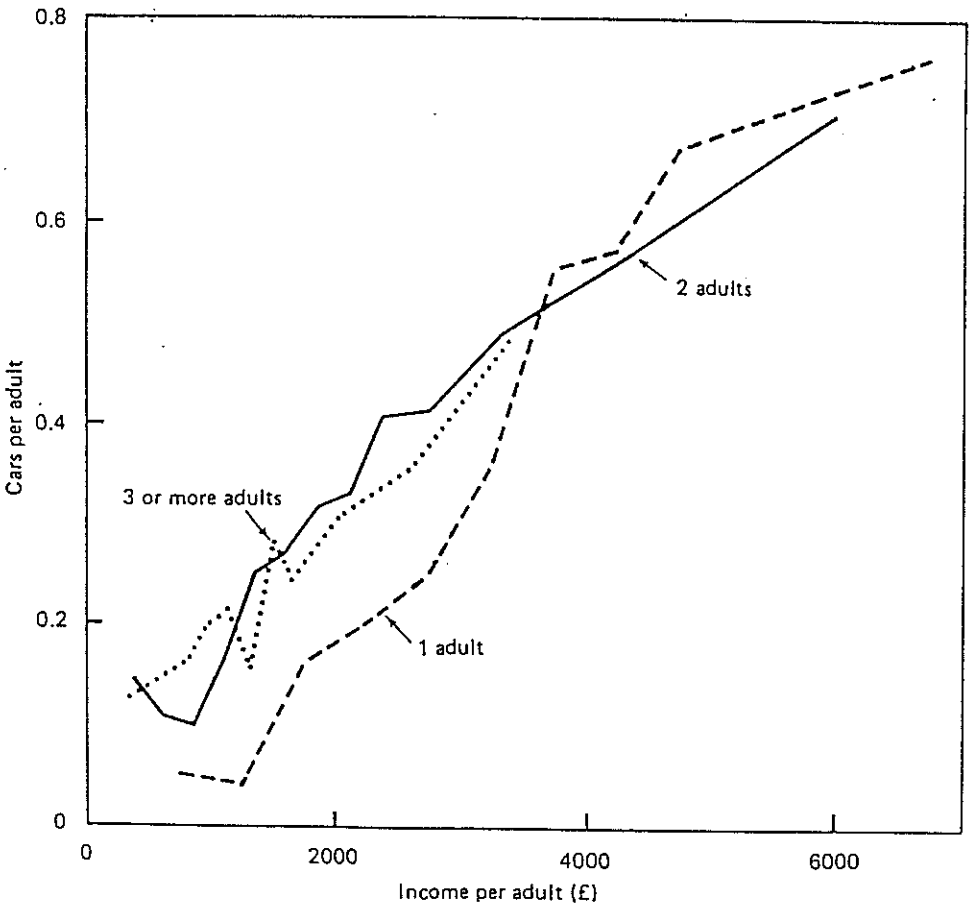


Figure 2.7 Cars per adult and income per adult, from UK National Travel Survey of 1978-79.



In Australia, about 5% of the potential car-owning population are unable to use a car because of disability, mainly because of advanced age or poor eyesight. With ageing of the population, this proportion may increase somewhat in future.

The proportion of the potential vehicle-owning population that chooses not to own a car will vary depending on location. No doubt vehicle ownership in major conurbations such as London, Tokyo and New York, is significantly below that in smaller cities and rural areas. However, much of this is related to physical constraints on vehicle ownership and use, particularly congestion and parking problems. The effect of public transport provision on vehicle ownership levels (which is discussed in Appendix A of this report) is probably equivalent to around 0.05 vehicles per person at current levels, based on UK, European and Australian analyses. Whether this impact will be maintained as saturation approaches can only be a matter of conjecture at this stage.

In summary, no evidence shows that the saturation level of vehicle ownership can be determined by applying statistical techniques to past data. The most sensible approach is to look at the behaviour of the vehicle-owning population that has a relatively high income level. To date, useful data for this approach are available only from the US. The indications from US data are that vehicle ownership will saturate at around 0.95 cars per adult.

The major influences on this saturation level are:

- the proportion of the population permitted by law to drive a car,
- the proportion of the potential car-owning population unable to own or drive a car because of physical or mental disability,
- the proportion of the potential car-owning population who choose not to own a car for such reasons as physical constraints (road congestion and difficulty of parking) or the availability of public transport.

3. Potential Modelling Approaches: Literature Review & Appraisal

3.1 Introduction

Two principal approaches have been used in modelling vehicle ownership over the last 20 to 30 years, with a third more recent approach being given particular attention in recent years. The first two are:

- The *macro-economic approach* which undertakes a time-series analysis to relate the changes that have been observed in vehicle ownership over time, to aggregate variables such as total population, gross domestic product (GDP), and the cost of motoring.

- The *micro-economic approach* which involves analysis of cross-sectional data. Usually household-based data are used, although person-based models have been investigated by some researchers, e.g. Mullen & White (1977). The use of these models for forecasting requires aggregation to a zonal or regional level.

The *macro-economic approach* has the advantage of being economical in its data requirements but, because of the aggregate level at which it is conducted, omits many variables which affect car ownership at the household level. Nevertheless, these models, because of their strong statistical basis, generally perform reasonably well over the short- to medium-term. In the longer term, there is considerable uncertainty that the modelled relationships will continue to hold, and complete reliance on this approach alone is fraught with danger.

The *micro-economic approach,* by contrast, often includes a large number of variables at the disaggregate level. However, some of these variables often contribute very little to the explanation of changes in car ownership over time. Other variables may be difficult to forecast reliably. There is also a danger that the assumptions necessary to move from the individual household to an aggregated zonal or regional level may be so crude that the model's superior performance at the disaggregate level disappears during application.

However, the main disadvantage of the micro-economic approach has been the general experience that the model, which is usually calibrated on cross-sectional data, does not perform credibly over time, invariably under-estimating the growth in vehicle ownership. We comment further on this aspect later in this chapter.

- The *cohort processing approach* which is based on modelling the car-owning behaviour of people as they age and move through various stages of their life cycle.

This third basic approach to modelling vehicle ownership, which has been given particular attention recently, is discussed towards the end of this chapter.

3.2 Macro-Economic Modelling Approach

3.2.1 United Kingdom

The most well-known work in the UK was undertaken by Tanner at the Transport and Road Research Laboratory (TRRL), UK, culminating in TRRL Report LR799 (Tanner 1977). The model used a power curve and incorporated the following features:

- an ultimate saturation level,
- an income variable,
- a motoring cost variable,
- a variable to represent the passage of time, serving as a proxy for a complex of unidentified factors.

The Tanner model did not explicitly recognise the influences of other factors such as policies adopted towards road provision, traffic restraint and public transport support. Continuation of existing policy trends was implicitly assumed.

This model has now been generally discredited, after being subjected to intense examination from various public inquiries for road schemes. The weakest part of the methodology was the determination of a saturation level which Tanner attempted, using a series of ingenious manipulations of the data.

3.2.2 Australia

Wadhwa (1981) developed alternative models of vehicle ownership for Australia, which were then used to forecast vehicle-ownership levels through to the year 2000. Linear and logistic models were tested using both time and income as explanatory variables.

The linear model had the limitation that growth continued indefinitely and the time-logistic curve was only statistical. It was not a causal model in that the growth of vehicle ownership was not related to any economic-social-behavioural variable. Wadhwa applied this model to forecast vehicle-ownership levels for metropolitan cities by applying a factor based on the population of the city. Vehicle ownership per person by zone or local government areas of each metropolitan city was estimated using the log of the residential density as one of the explanatory variables. This variable was considered a proxy for the availability and quality of public transport.

The approach adopted by Wadhwa for urban areas is suitable for use in regional policy studies. However the use of the model in detailed transport studies is limited.

3.3 Micro-Economic Modelling Approach

3.3.1 United Kingdom

The UK zonal car-ownership model used to produce the 1989 forecasts by the UK Department of Transport (DoT 1989) is the latest version of a development stream commenced in 1971 by Bates (1971). It was followed by the "Research Report 20 (RR20) model" developed by Bates et al. (1978a), the "Regional Highway Traffic Model (RHTM)" developed also by Bates et al. (1978b), and culminated in the current "Licences Per Adult" model (DoT 1984). The 1989 update (DoT 1989) to the latter involves the same model but uses different assumptions on the independent variables.

All these models were based on cross-sectional data, disaggregated at the household level.

Bates (1971) analysed the Family Expenditure Survey and National Travel Survey data and developed a logistic model using household income as the explanatory variable, achieving an R^2 of 90%. Bates also demonstrated that, because the average income level at which more than 50% of households own cars was apparently falling over time, the model was unstable over time. To explain this, Bates developed arguments relating to changes in the used car market and changes in taste. (Golob (1989) had similarly concluded that the relationship between income and car ownership was unstable over time.)

Bates' equations, although based on a sample of several thousand households, were obtained by aggregating all the households into twelve income groups, and then regressing the group average values of non-car ownership against the average values for income. This had the effect of eliminating any variance related to household size or public transport accessibility.

Fairhurst (1975) has commented that the true importance of income was undoubtedly less than suggested by Bates, because of aggregation effects which eliminated location-specific effects. Fairhurst developed a similar model to Bates, using data from the 1962 London Transportation Study (LTS), which resulted in a much lower R^2 of 40%. The LTS data gave a different impression of the importance of income because the area aggregation used by Fairhurst:

- eliminated extreme income values,
- did not eliminate variance due to public transport accessibility,
- only partially eliminated variance due to variation in household size.

Fairhurst developed this model further to include household income, household size and public transport accessibility as the explanatory variables, and achieved an R^2 of 80%: the component explanatory factors were income (40%), household size (32%), and public transport accessibility (8%). Fairhurst also tested a model which used household income and net residential density as the explanatory variables.

He claimed that this form of model would be an unsatisfactory predictive tool in a period of declining household size and declining public transport attractiveness by referring to the work of Quarmby & Bates (1971).

They calibrated such an equation on NTS data. However, attempts to validate the model by back-forecasting to 1959 showed that the equation seriously under-estimated the increase in car ownership over the period. This proved so intractable that the model was abandoned.

As a national forecasting tool, the RHTM model (Bates et al. 1978b) differed from the earlier cross-section models based on Family Expenditure Survey data (Bates 1971; Bates et al. 1978a) only in having an additional variable, that of accessibility. Accessibility in this case is a measure of density rather than the relative accessibility of highway and public transport. Bates et al. (1978b) compared the RHTM model with the macro-level model (LR799) used by Tanner (1977) and made the following conclusions:

- Both models implied that the growth in car ownership would decline more or less continuously, and that there was an effective saturation level.
- Both models took account of the effect of prices and incomes.
- The crucial distinction rested on the weight which was given to the economic variables in the two models.

  The RHTM model assumed that all growth in car ownership could be explained in terms of the economic variables, household income and the price of cars.

  Tanner, on the other hand, considered that only half the growth was attributable to the measured economic variables, and that the remainder could be effectively modelled by a time trend, serving as a proxy for a complex of unidentified factors.

Doubts about the forecasting accuracy of the RHTM model arose when Family Expenditure Survey data for the years 1976-78 became available. These data indicated that the conclusion of RR20 (that deflating income by the Car Price Index would ensure a time-stable model) were not valid (MVA 1980; Bates & Roberts 1980). The UK national model described in RR20 predicted that car ownership would fall over the period 1975-78, because car prices rose more rapidly than real gross household incomes. In fact, car ownership continued to increase and the model under-estimated the 1978 level by 16%. The model was then adjusted, with the new independent variable being gross household income deflated by the Retail Price Index.

The UK DoT has since replaced both models with a new model, based on cross-sectional data, which is similar in form to the RR20 model, with independent variables of gross household income deflated by the Retail Price Index and driving licences per adult (DoT 1984, 1989). The latter variable is clearly highly correlated with the dependent variable (car ownership), and as licences per adult are forecast to follow a time-logistic curve, it would appear that this variable is included in the model as a time trend, serving as a proxy for unidentified factors.

In summary, the micro model developed initially by Bates, and subsequently the "RR20" model and the "RHTM" model, did not perform credibly over time, invariably under-estimating the growth in car ownership. All these micro models achieved a high statistical explanation by using household income as the explanatory variable in the cross-sectional analysis. This result was not surprising given the aggregation techniques used, for these had the effect of eliminating any variance related to household size or public transport accessibility. Fairhurst (1975) and Tanner (1977) have both claimed that the true importance of income is only half that reported in the above models.

Tanner considered the remainder of the explanation for car-ownership growth could be effectively modelled by a time trend, serving as a proxy for a complex of unidentified factors. Fairhurst speculated that the remainder of the car-ownership growth would be explained by declining household sizes and declining public transport attractiveness.

3.3.2 Australia

The general approach in Australia in recent years has been to estimate an overall level of car ownership based on existing trends, but also to distribute vehicles within an urban area based on micro-analysis. This approach has been used by the Ministry of Transport in Sydney (Groenhout & Bell 1985), the RCA and Travers Morgan (1981) in Melbourne, and Travers Morgan (1982) in Perth.

The general experience, which is supported by these two detailed car-ownership models by Travers Morgan (in Perth and Melbourne), is that use of cross-sectional models alone strongly under-estimates the growth in car ownership when back-projected. This occurs even though both models took account of changes in household size, and the Perth model was able to account for changes in public transport accessibility. Our view is that the remainder of the car-ownership growth can only be explained by changes in consumer taste and/or by progression through the human life-cycle (section 3.4 of this report). This means that, for a given level of income and household category, the level of car ownership has been increasing over time, because of changes in each generation's perceptions of the need for, or difficulty in, owning a car.

3.4 Cohort Processing Models

One strand of recent research has focused on explaining the underlying factors that:

- contribute to the increase in car ownership over time for a constant income and household category,
- make the relationship between income and car ownership unstable over time,
- explain the time trend that has served as a proxy for unidentified factors in numerous car-ownership models during the last 20 years.

This strand of research has also been motivated by the apparent increase in importance of the "time-trend" factor in recent years, as the generally slower rate of income growth observed in most developed countries in the 1970s and 1980s has not been accompanied by a corresponding slower rate of increase in car ownership.

The explanation of this experience has been attributed by many researchers to changes in preferences or taste in favour of the private car. These changes are highly correlated with time, allowing earlier researchers to use time as a proxy for these factors and thus "solve" the problem without having to investigate the real effects at work, in more detail.

One approach to this issue is to study the way in which different age groups make net contributions to changes in car ownership. For example, the age groups containing the youngest legally entitled car drivers are dominant in terms of new car owners. This increase in car ownership by the younger groups is not at all matched by higher age groups leaving the car-owning population. Only the retired age groups leave the car-owning population in significant numbers, while car-ownership in the 30- to 60-year age groups hardly changes.

This result arises because, among the non-car owning population, a younger person is more likely to acquire a car than an older person. This is in line with general consumption habits, which in later life becomes increasingly stable. This implies that a younger person is more likely to own a car than an older person with the same income and, as the young person enters a higher age group, he/she takes this habit along. It follows that car-ownership will increase simply through the ageing of the population. This underlying increase generally dominates any tendency for people to reduce their car ownership when faced with short-term reductions in disposable income.

This so-called "diffusion effect" can be modelled through a "cohort processing" model. The features of this model compared to traditional models are:

- persons rather than households form the basis of the model,
- age replaces income as the principal independent variable.

Jansson (1989) regarded the entry and exit propensities (i.e. the proportion of non-car persons acquiring, and the proportion of car-owning persons leaving, car ownership during a particular year) by age cohort to be the primary dependent variables. Car-ownership levels were then estimated using demographic data.

By using observed entry and exit propensities, and birth and death rates, in Sweden for a fixed year, Jansson simulated the car-ownership levels for future years assuming fixed prices and incomes. The simulation showed that car-ownership levels would continue to increase and that an equilibrium would not be reached until after about 75 years had passed, when the propensities and birth and death rates had been constant for a whole generation.

By separating the increase in car ownership caused by demographic changes and past propensity shifts from that related to future propensity shifts, a much better understanding was obtained of the observed insensitivity of car ownership levels to short-term fluctuations in the economy.
The analysis showed that entry propensities had actually fallen in the period 1975-1982, due to lower disposable incomes and higher fuel prices; but that this effect was more than outweighed by the demographic effects, thus resulting in overall car-ownership increases.

The approach taken by Jansson is, however, very data-intensive, requiring income and car-ownership information for each age cohort in the base year. In addition, detailed age distribution forecasts are required.

Another example of a cohort processing model is provided by van den Broecke (1988). He divided the population using five dimensions:

- five-year birth periods
- sex
- education level
- partnership status
- economic position

As birth year and sex do not change, and education level can be assumed to be fixed after one's early 20s, and forecasts exist for the remaining two dimensions, van den Broecke could estimate the corresponding 5-dimensional population matrices for future years. By assigning an income level to each matrix cell for the base year and making assumptions on income growth and its elasticity with respect to car ownership, future car-ownership forecasts were developed.

In summary, a number of features of cohort processing models makes them conceptually attractive:

- With high car-ownership levels, a car is becoming more of a personal item than a household item, thus making a modelling approach based on persons rather than on households intuitively attractive.
- Household characteristics are correlated with age to a large extent and a household is becoming a more loosely defined concept in modern developed countries.
- The complexities inherent in forecasting the numbers of households by category for future years are eliminated. Forecasts of persons by age and sex are more readily available.
- The models can separate the increases in car ownership related to future demographic changes, given current behavioral patterns from the increases related to changes in income, etc. Such an analysis should give a better understanding of the likely saturation level.
- As future increases in car ownership will largely come from increased car ownership among the older age groups, an age-based rather than an income-based analysis appears more attractive.

A serious drawback of this type of model is the extensive data requirement. In both Sweden (Jansson 1989) and the Netherlands (van den Broecke 1988), appropriate data of individual car ownership by age and income level are available. This type of data is not available in New Zealand on a national level.

3.5 Conclusions

Macro-economic models generally perform reasonably well over the short to medium term. However, there are several limitations:

- Because of their strong statistical basis, there is considerable doubt that the modelled relationships will continue to hold in the longer term.
- There is no evidence that statistical techniques applied to existing data can be used to forecast the saturation level, which is a long-term phenomenon, with any certainty.
- The models cannot be used to distribute changes in the level of ownership within a region.

The main disadvantage of the conventional micro-economic approach is that the models do not perform credibly over time, invariably under-estimating the growth in car ownership. Changes in taste and attitudes, together with life-cycle progressions, are thought to be the main reasons for this under-estimation.

A cohort processing model would appear to largely overcome this problem in that it gives an adequate explanation of the so-called "taste" factor. However it requires extensive detailed data for forecasting car ownership by age and income over time.

4. Trends & Data Sources for Vehicle Ownership in New Zealand

4.1 Data on Vehicle Ownership

4.1.1 Data Sources for Vehicle Registrations

Originally a time series of past vehicle ownership in New Zealand was expected to have been taken directly from published statistics. However, this proved to be not the case, particularly because in the last few years changes had occurred in the "standard" method of recording the number of registered motor vehicles. Hence considerable investigations had to be made in order to estimate a consistent and realistic time series of vehicle ownership at the national level. These investigations are summarised here and a "best" time series has been derived.

New Zealand vehicle registrations are maintained by the Motor Registration Centre (MRC), a division of the Land Transport Safety Authority (LTSA), under contract to the Ministry of Transport (MOT). Three time series, which have been derived from the MRC data, are readily available:

1. Tables of "Licensed Motor Vehicles" in the transport section of the New Zealand Yearbooks (produced by Statistics NZ). This series is based on the MRC March Quarterly Return. It represents the number of motor vehicles licensed at 31 March each year: figures are available from 1951, broken down by vehicle type.

2. Tables of "Vehicles Registered", in "Motor Accidents in New Zealand", a report produced annually by the LTSA. This series was originally based on the MRC December quarterly return, and represented the numbers of vehicles registered at 31 December each year. It includes vehicle categories not included in the Yearbook series: Exempt Vehicles, Tractors, Trade Plates, and Caravans. Only aggregate figures are provided.

3. Tables of vehicles licensed by quarter before 1987, and by month after 1987, held by Statistics NZ. This series is also based on the MRC returns, is available from 1970, and is broken down by vehicle type.

A new licensing system was introduced in 1987. No figures were provided by the MRC in 1987, and the 1988 figures were some 10% lower than those for 1986. Given the long-running upward trend in vehicle registrations, this was obviously unrealistic and prompted further investigations about the compilation of the figures. Discussions with MRC and LTSA staff provided the following information.

Before 1986

- Motor Registration had a manual recording system.
- All motor vehicles were re-licensed annually at the same time of the year.
- De-registered vehicles were deleted from the record of licensed vehicles only once a year, after the end of the June quarter. All the quarterly returns therefore included vehicles scrapped (i.e. de-registered).
- The quarterly returns represented the total number of licensed vehicles at the end of that particular quarter, i.e. all vehicles licensed at the end of the quarter plus any other vehicles which were licensed from 1 July for which licences may have subsequently been de-registered.

From 1987

- A computerised recording system was installed in 1987.
- The statistics provided from 1987 represent the number of current licensed vehicles at the date of reporting.
- Vehicles which are de-registered are removed from the computer records immediately and therefore from the number of licensed vehicles at the date of reporting.
- The new computer system coincided with the introduction of the new spread re-licensing system. The new system had licensing periods of both 6 months and 12 months, and licence expiry dates spread throughout the year.
- The change to reporting statistics "as at" a certain date rather than "for the year ended", and the new spread re-licensing system meant that a significant proportion of vehicles were not recorded in the annual statistics because their licence was paid late after the due date.

We conclude from this that:

- The MRC statistics before 1987 were an over-estimate of the number of vehicles licensed at any one time, because de-registered vehicles were not being removed from the totals.
- The MRC statistics after 1987 represent the number of vehicles for which licences were strictly valid at any one time, not allowing for any late re-licensing. These should be added in to reflect the total "active" vehicles at any one time.

4.1.2 Best Database

Having reviewed the three main sources of time series data on New Zealand motor vehicle ownership, the Statistics NZ data (September quarter) was to be used as the basis from which to derive a consistent time series.

This decision was based on the following considerations:

- All three time series are based on the MRC data, and would be suitable as the basis for a historical time series.
- The Yearbook data, which reports licensed vehicles at the end of March each year, includes a higher proportion of scrapped vehicles before 1987 than does the Statistics data. The Yearbook data will therefore give a less accurate representation of active vehicles than the Statistics data.
- The LTSA figures will also be a less accurate representation of active vehicles than the Statistics data. They represent licensed vehicles at the end of December each year and, since 1986, they have been estimated using a simple spreadsheet model. The LTSA is reviewing its methodology for this time series, and does not consider that it would provide an accurate basis for forecasting future vehicle ownership levels.

The three time series are shown in Table D1, Appendix D of this report.

4.2 Project Estimates of Vehicle Ownership

4.2.1 Method

For purposes of this project, we required a time series on a consistent basis of annual figures for the numbers of "active" vehicles (cars, motorcycles) in New Zealand.

As detailed in section 4.1 above, the September quarter data from the Statistics NZ MRC database was used as the basis for this time series. However, several issues had to be addressed in developing the time series, and these are discussed below.

- *Scrapped Vehicles*
  Before the introduction of the computer-based re-licensing system in 1986, vehicles which were scrapped during the year continued to be counted as being licensed until the end of June, at which time all de-registered vehicles were removed from the records. Thus, the MRC-based records always included some "inactive" vehicles, with the number of these increasing during the year from July to June.

  Analysis conducted by the Land Transport Division (LTD) of the MOT in the early 1990s concluded that the proportion of scrapped vehicles ranged from between 3% pa and 6% pa of licensed vehicles for the period 1970 to 1992, averaging out to 4.4% pa over that period. Using the September quarter figures minimises the number of scrapped vehicles being counted as "active". However, a small number of scrapped vehicles will still be included in the Statistics NZ numbers. The pre-1986 figures have therefore been adjusted downwards by 1% to reflect this (1% being one quarter of the average annual proportion).

- *Late Re-licensing*
  Before 1986 all vehicles were counted by MRC as being licensed, unless they had actually been de-registered. This meant that vehicles which were re-licensed late were also counted in the total of licensed vehicles. However, since 1986 the figures released by MRC to Statistics NZ have been the actual number of vehicles with current licences. This means that the post-1986 figures are an under-estimate of "active" vehicles as they do not include late registrations.

  An analysis by the MOT Land Transport Division in 1992 over a 6-month period concluded that about 8% of active vehicles were not re-licensed at any one time. We analysed two sets of vehicle licensing data, one which was gathered by the MOT and one by the LTSA. This analysis found that the number of all "active" vehicles unlicensed at any one time was 4% and 5.5% of the total licensed vehicles. (This analysis assumed that all vehicles re-licensed within 12 months of their anniversary date were "active".) We have therefore increased the Statistics NZ post-1986 data by 5% to account for late registrations.

- *Semi-permanently Unlicensed*
  We have not made any adjustments for vehicles which are unlicensed for more than 12 months, although it could be argued these should be made. The MOT's broad estimates are that these are about 1-2% of all vehicles (reliable data are not available).

- *Vehicle Categories*
  Vehicle categories have changed over time. However, the Statistics NZ data are sufficiently detailed so this variation could be accounted for in the vehicle totals.

4.2.2 Results

After applying the above adjustments to each vehicle type, Table D2 in Appendix D of this report shows our estimates of annual vehicle ownership in New Zealand by vehicle type since 1970.

The adjustments have involved:

- A reduction in the Statistics NZ September figures pre-1986 of 1%.
- An increase in the Statistics NZ September figures post-1987 of 5%.

4.2.3 Trends in Vehicle Ownership

Figure D2, in Appendix D, shows the trends over the period 1970-1996 in vehicle ownership in New Zealand using our best estimates (Table D2, Appendix D), plus the breakdown into main vehicle categories, i.e. cars, motorcycles, goods trucks and buses.

Key features of the results include:

- Total of 2,215,000 vehicles at September 1996.
- This total comprises 80.5% cars, 2.1% motorcycles, 16.9% goods trucks, and 0.5% buses.
- Numbers of cars and goods vehicles have increased almost every year throughout this period. Apart from the 1986/87 "blimp", which has been resolved partially by the adjustments made, the only recent exception to this steady upward trend was in 1992 when the number of cars dropped slightly for the first time in 20 years.
- Numbers of motorcycles increased rapidly in the 1970s, peaked in the mid-1980s, and has since decreased from that peak by almost half.

Table D3 and Figure D3, in Appendix D of this report, show the trend in cars and motorcycles per person over the last 25 years. Table 4.1 below summarises the increases in car ownership over the consecutive 5-year periods during that time.

It is apparent that:

- The absolute change in cars/person over each 5-year period has decreased over the last 25 years, being at its highest in the period to 1975, with an average of 57 cars/1000 persons, and dropping to 18 cars/1000 persons for the period to 1995. However, it was very similar in the other three periods, ending 1980, 1985 and 1990, at around an average of 34-40 cars/1000 persons.
- The proportional rate of increase in cars/person has fallen, from 3.4% pa average in the period to 1975, to 1.5%-1.9% in the three periods up to 1990, and then down to 0.7% in the 1990-1995 period. However, in the seven-year period 1988-1995, the increase in cars/person was 1.5% pa average.
- The absolute change was significantly lower in the period ending 1995. The data appear to show that car ownership is increasing at a reduced rate over time. This may indicate that car ownership is approaching saturation level.

Table 4.1 Summary of car ownership changes by 5 year period.

5 years ending	End Cars/Person	5-Year Increase in Cars/Person		
		Absolute	Total %	Ave % pa
1970	0.310			
1975	0.367	0.057	18.3	3.4
1980	0.402	0.034	9.4	1.8
1985	0.442	0.040	10.0	1.9
1990	0.476	0.034	7.6	1.5
1995	0.493	0.018	3.7	0.7

4.2.4 Comparisons with Other Countries

Figure 2.1 in this report shows that the trend in vehicles/person in New Zealand has closely paralleled that in other English-speaking countries since the late 1950s (at least). The New Zealand absolute vehicle-ownership levels have, throughout the period, been very close in absolute terms to those in both Canada and Victoria (Australia). They have been around mid-way between the levels in the US (latest average 0.6 in 1989) and those in the UK (0.37 in 1989).

4.3 Analysis of Past Trends of Vehicle Ownership

4.3.1 Data Sources

For analysis purposes, time series data on the following further statistics have been assembled:

(i) NZ population total
- mean population for year ending 31 March
- for years 1955 - 1996
- from Statistics NZ

(ii) NZ real GDP
- annual GDP for year ending 31 March
- for years 1955 - 1996
- expressed in constant prices (NZ$1982/83)
- from Statistics NZ

(iii) NZ average car purchase prices
- average prices of all cars purchased (new and second-hand) in NZ
- for year ending 31 March, as used in CPI composition
- years 1966 to 1996
- special analysis from Statistics NZ

4.3.2 Analysis of Trends

An analysis was undertaken to investigate the extent to which vehicle-ownership levels might be affected by changes in real income (GDP per person) and changes in real car prices.

Figure 4.1 graphs the moving 3-year average change in cars per person, real GDP per person and car prices since 1973.

Figure 4.1 Three-year change in cars per person, GDP per person, and car prices for the period 1973-1996.

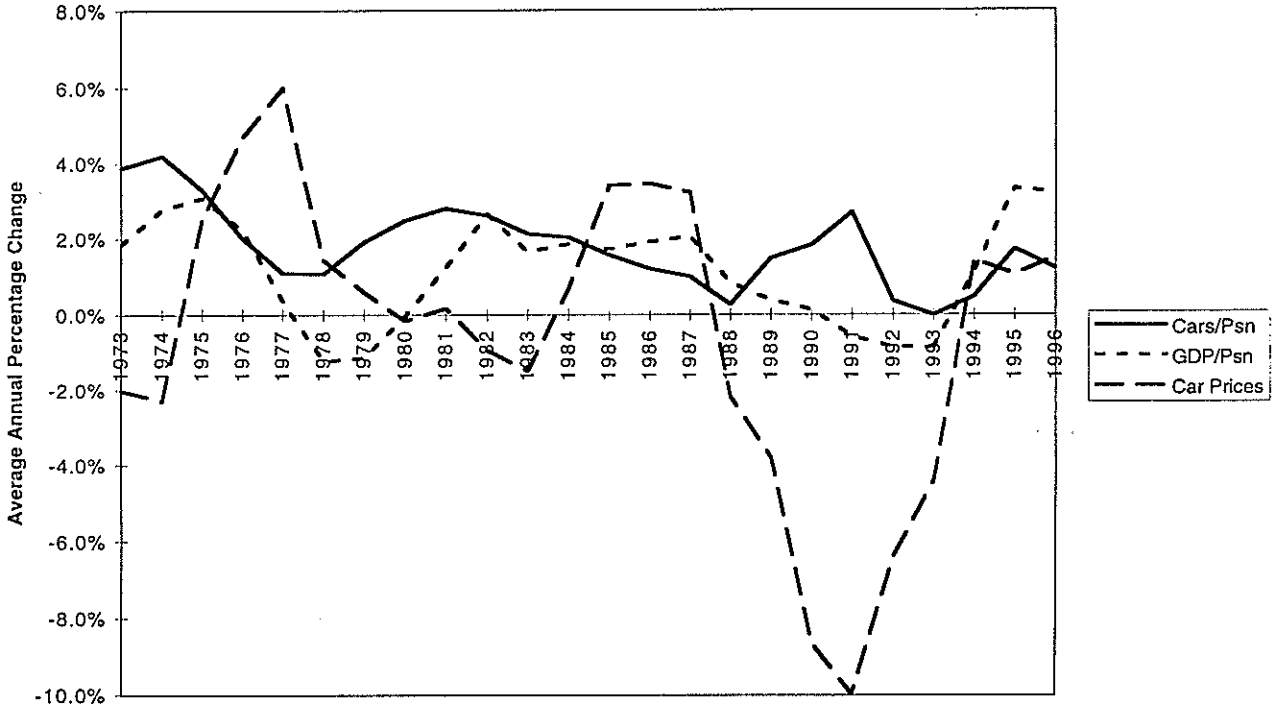
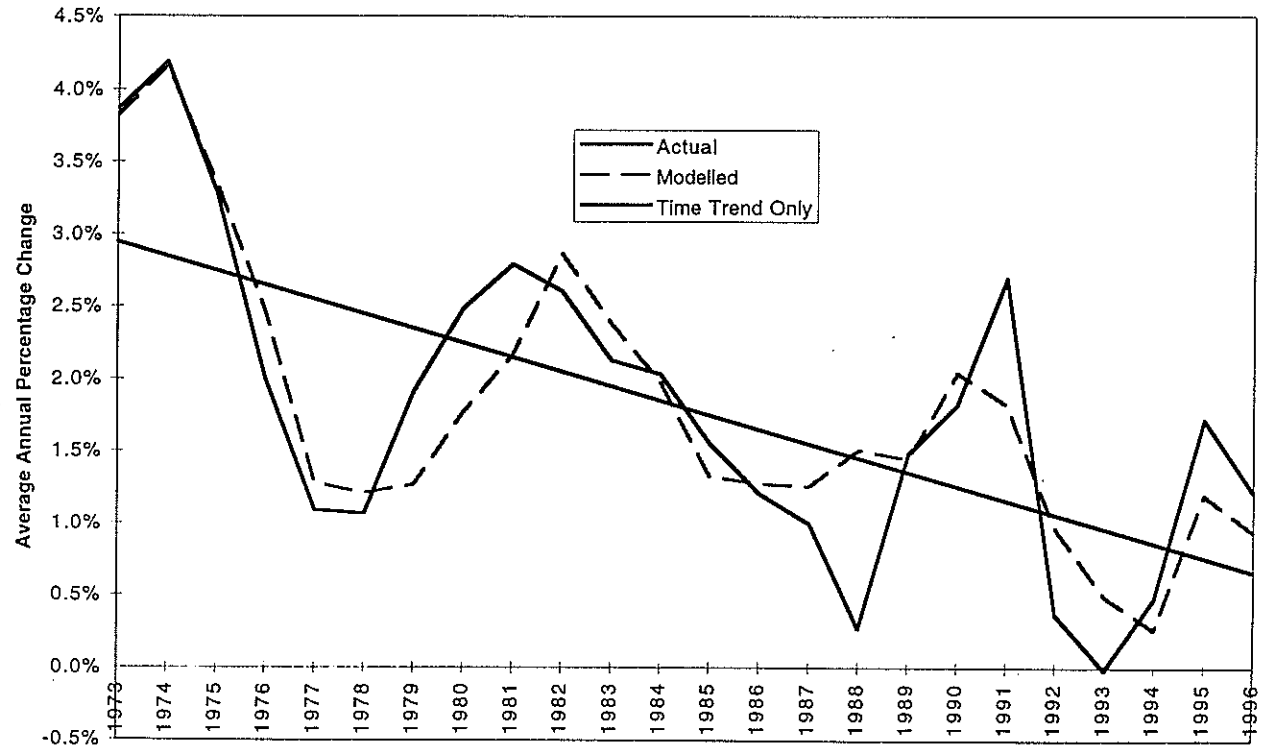


Figure 4.2 Regression of 3-year moving average of changes in real GDP per person, and real car price against cars per person, for the period 1973-1996.



This suggests that:

- A reasonable correlation exists between growth rates in cars/person and in GDP/person, on a 3-year average basis. The cars/person growth rates are less volatile than the GDP/person growth rates. There is no clear evidence that the car/person trend either leads or lags behind the GDP/person trend.
- The substantial reduction in car prices in the period after 1988 appears to be a major factor, which influenced the strong growth in car ownership over the 1988-1991 period when GDP growth was very weak (or negative).

In the light of these initial findings, two linear regressions were undertaken to further examine the relationship between the 3-year moving average statistics for annual percentage changes (Figure 4.2):

(A) Cars/person against GDP/person and Car Price.

(B) Cars/person against GDP/person, Car Price, and Time.

Regression (A) provided a moderately good explanation of the trend in cars per person. Regression (B) provided a much improved fit, indicating a substantial decrease in the annual time trend over the period. The results for Regression (B) are summarised in the following table.

Time Trend	3.0% pa in 1970, decreasing by 0.1% pa to 0.6% in 1996
Elasticity of cars/person with GDP/person	+ 0.43
Elasticity of cars/person with Real Car Price	- 0.17

The following conclusions are drawn from this analysis:

- Over the period 1970-1996 average annual changes in cars/person were strongly correlated with changes in GDP/person, real car prices, and a steadily diminishing time trend.
- The apparent "unexplained" time trend reduced rapidly over the period by an average 0.13% pa. This is relatively faster than the rate of reduction before 1970, which was about 0.08% pa over the period 1958 - 1970.
- The reasons for the relatively rapid change in the time trend are not totally clear. They are probably related to social and demographic factors rather than to economic factors. They may indicate that car ownership is approaching a "saturation level" (with zero underlying time trend), with any further increases being primarily the result of economic factors. However, this is far from clear and would warrant further investigation.
- Changes in GDP/person and real car prices "explain" much of the variation in cars/person about the time-trend line over this period. There appears to be little lag between the GDP and car price changes, and the car ownership response.

Figure 4.3 Vehicle ownership according to number of vehicles per person, by region and for all New Zealand, for the period 1986-1996.

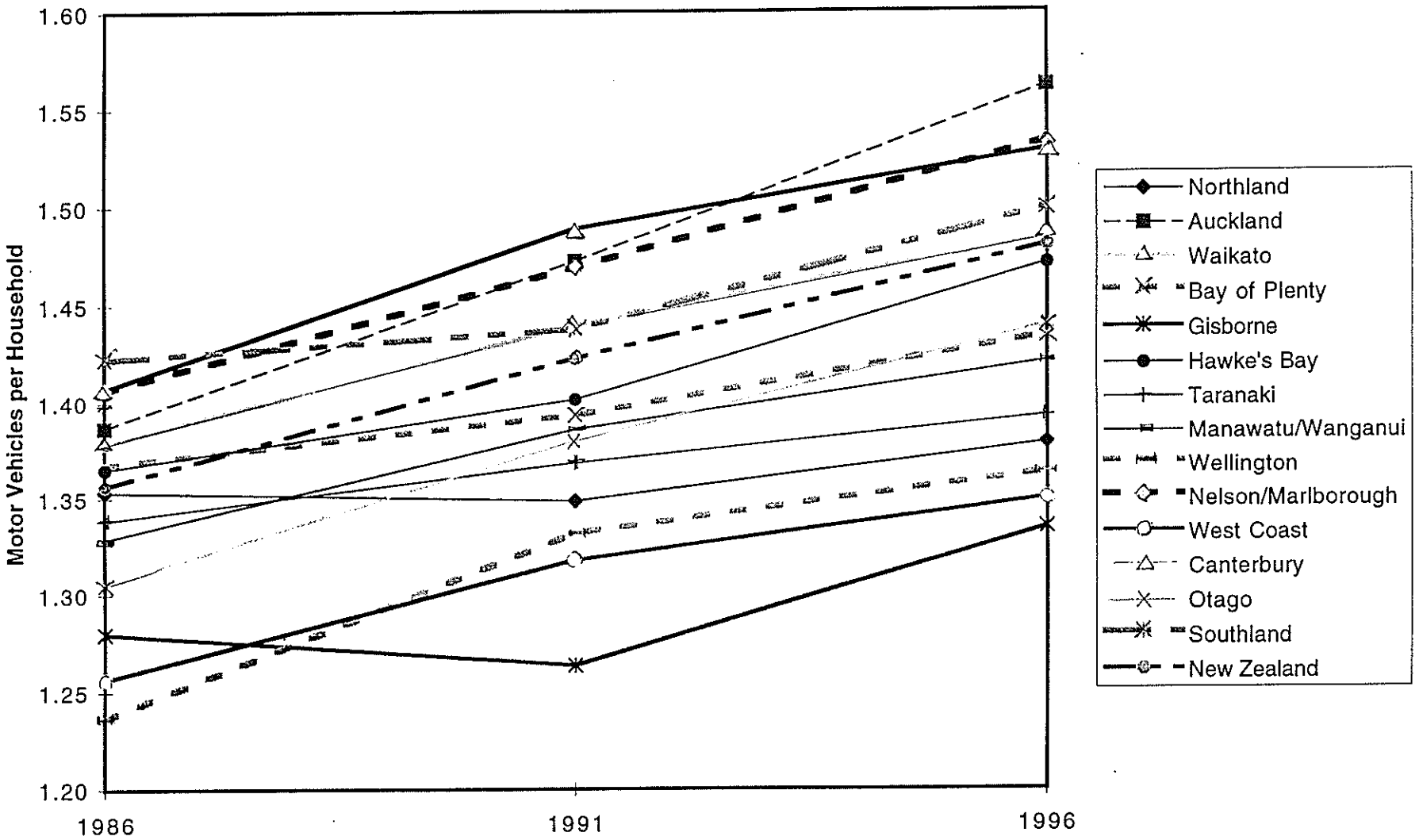
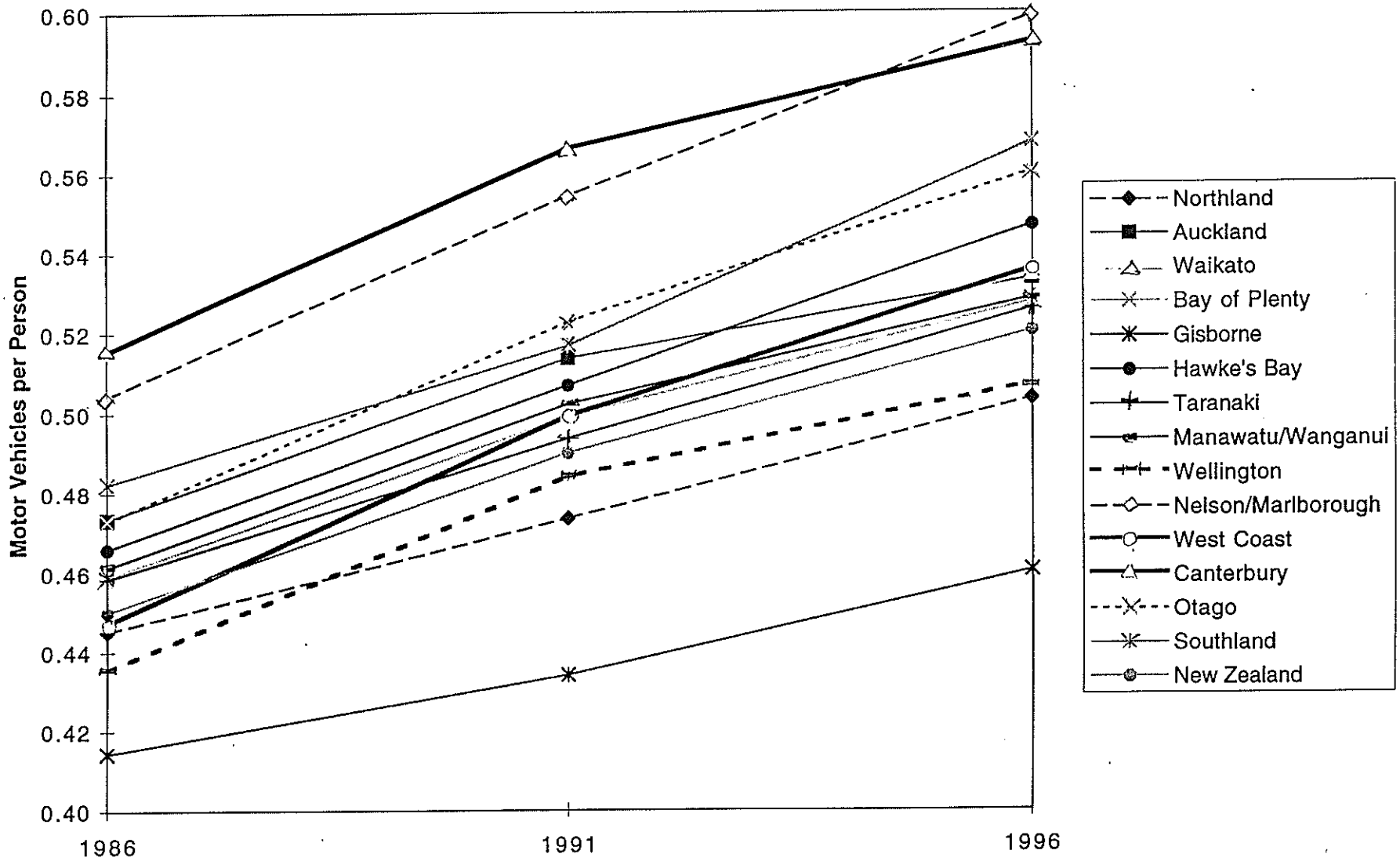


Figure 4.4 Vehicle ownership according to number of vehicles per household, by region and for all New Zealand, for the period 1986-1996.



- The regression indicates an elasticity of cars/person with respect to GDP/person of +0.43, and with respect to car price of -0.17. The elasticity with respect to GDP/person compares well with the figures estimated in a previous project (National State Highway Strategy, Working Paper D, TNZ) suggested an elasticity of 0.45 for Vehicle Kilometre Travelled with respect to $ GDP increase).

4.4 Vehicle Ownership in Different Regions: Census Data

4.4.1 Analysis of Census Data

Tabulations have been obtained from the 1986, 1991 and 1996 Censuses, of the proportions of households in each region of New Zealand owning different numbers of vehicles, the average vehicles per household and vehicles per person in each region. The motor vehicle-ownership per person from each Census by region is graphed in Figure 4.3 "Vehicles per Person", and in Figure 4.4 "Vehicles per Household".

In this context, the numbers of vehicles recorded are those available for private use in the care of persons in the dwelling on census night. It includes cars, station wagons, vans, trucks and other vehicles used on public roads, and also any business vehicles available for private use; but it excludes motorcycles/scooters and tractors, and any business vehicles not kept at private dwellings (no divisions by vehicle type are available).

Notable features of these statistics include:

- Nationally, the average vehicles per household has increased from 1.36 in 1986 to 1.48 in 1996; and the average vehicles per person from 0.45 in 1986 to 0.52 in 1996.

- Nationally, the proportion of households with no vehicles has decreased from 13% in 1986 to 12% in 1996. The proportion with more than one vehicle has increased from 38% in 1986 to 45% in 1996.

- Auckland had the highest level of vehicles per household in 1996 at 1.56; however, Nelson/Marlborough had the highest level of vehicles per person in 1996 at 0.60, closely followed by Canterbury at 0.59 and Southland at 0.57. Auckland's ratio of vehicles per person in 1996 was 0.53. Gisborne had the lowest level of vehicles per household in 1996 at 1.33, and vehicles per person at 0.46.

4.4.2 Vehicle Ownership by Household Type

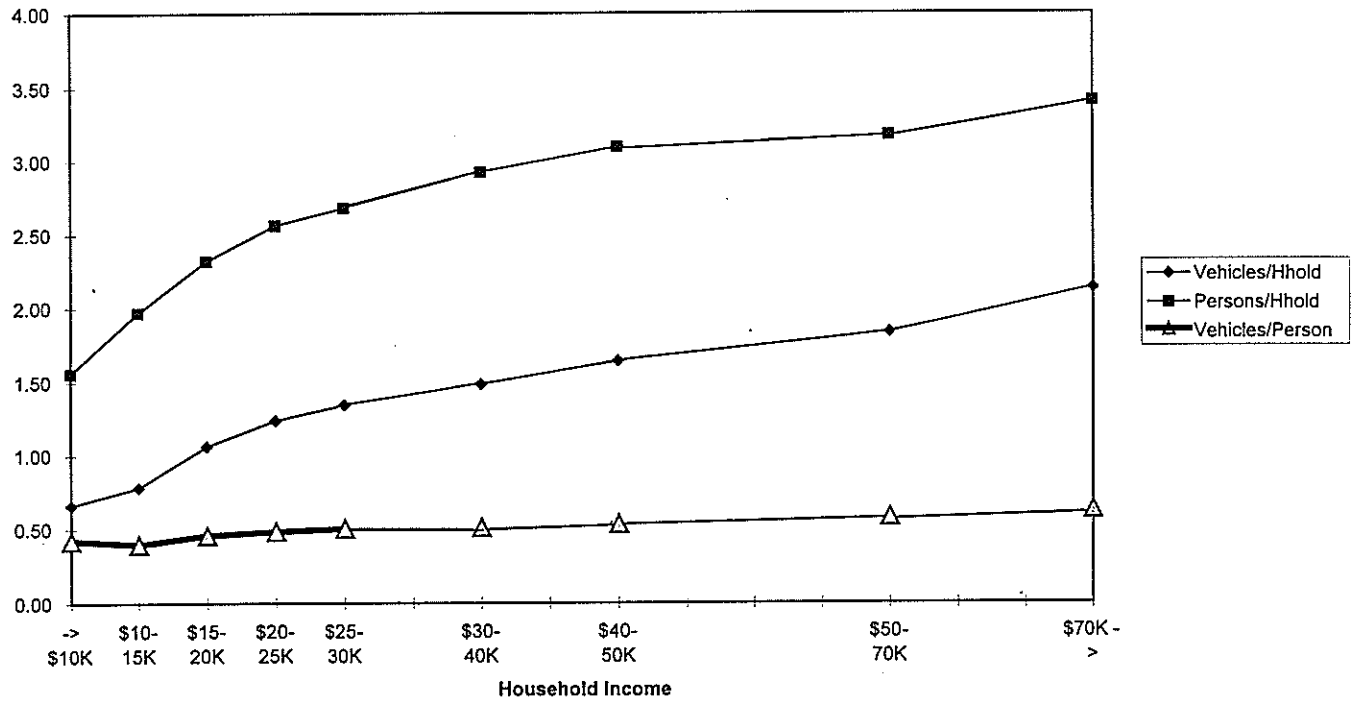
Further analysis of the 1991 Census data was conducted in regards to vehicle ownership by household type and family income group. Full details are given in Appendix E.

Notable findings include:

- Overall the average vehicles per household increases by a factor of about 3 from the lowest income group (0.66 vehicles/household) to the highest income group (2.13 vehicles/household). However, part of this increase may be ascribed to household size effects. The average vehicles per person increases by a factor of only 1.5 from the lowest income group (0.42 vehicles/household) to the highest income group (0.63 vehicles/household).
- Households that contain a greater number of adults tend to have more vehicles per household.
- Households that contain retired people tend to have fewer vehicles per household.

The relationship between vehicle ownership and household income is shown in Figure 4.5.

Figure 4.5 Vehicle ownership by income, obtained from New Zealand 1991 Census.



4.4.3 Reconciliation of Census and National Statistics

The Census data potentially provide the best basis for forecasting vehicle-ownership levels at the regional level, or at more detailed levels (Zonal or Territorial Local Authority (TLA)). Household number projections are also available at the regional and more detailed levels, and the Census vehicle-ownership data are household-based. However, the Census data do not represent all vehicles. Not only are motorcycles deliberately excluded, but company-owned vehicles which are not kept at private residences overnight are excluded.

The MRC statistics are the official records for vehicle ownership, and the Booz•Allen & Hamilton (BAH) vehicle ownership-time series is based on the MRC September quarterly returns. To enable estimates of vehicle ownership to be made at the regional level from census data, the Census data must be reconciled with the MRC statistics (cars only). A detailed analysis of the differences between the 1986, 1991, and 1996 Census and MRC data (March 1986, 1991 and 1996) was conducted, and is reported in Appendix E. The results are set out in Table 4.2, and are summarised below:

- The 1986 Census figure appears to be around 3 to 4% lower than the MRC figure. However, pre-1987 MRC figures are considered to be an over-statement of "active vehicles" (due to inclusion of scrapped vehicles) by 3% to 4%. The 1986 Census figures therefore appear to be a close approximation to the level of "active vehicles".

- The 1991 Census figure is around 6% higher than the March MRC figure. However, post-1987 MRC figures are considered to be around 5% below the level of "active vehicles" (due to exclusion of late re-licensed vehicles). The 1991 Census figure could therefore be taken as a reasonably close approximation to the level of "active vehicles", although slightly on the high side.

Table 4.2 Vehicles per person obtained from New Zealand data.

Source	Vehicles per Person		
	1986	1991	1996
MRC[1] - Original	0.467	0.462	0.460
- Adjusted	0.454	0.485	0.482
Census[2]	0.451	0.492	0.521
Ratio - Census:MRC Adjusted	1.00	1.01	1.08

Note: (1) MRC figures (March) - all cars, including rental cars & taxis
(2) Census figures - all vehicles used for personal use

The 1996 Census figure is around 13% higher than the March MRC figure. After taking account of the 5% under-statement assumed for post-1987 MRC figures, the 1996 Census figure is still around 8% higher than the MRC figure. No readily apparent reason has been determined for this difference. It is particularly confusing given the good reconciliation of the 1991 figures, and given that no changes in the definitions of either the Census figures or the MRC figures are believed to have occurred between 1991 and 1996.

Given that the MRC figures are likely to be more reliable than the Census figures (being based on actual transactions rather than survey responses), the 1996 Census figures cannot be taken as an accurate representation of "active vehicles". Further analysis would be required to determine the scaling factors which should be applied, and different factors may be applicable to different regions.

5. Proposed Modelling Approach

5.1 Introduction

The main thrust of this project is to develop a model or basis for forecasting future vehicle ownership for use in transport studies, traffic demand forecasting, and project evaluation throughout New Zealand.

This project has focused on providing:

1. A model or basis for forecasting vehicle-ownership trends at national and regional levels over the next 20 to 30 years;
2. A set of preliminary forecasts of future vehicle-ownership levels, developed on this basis.

The three different types of vehicle-ownership models (macro-economic, micro-economic, cohort processing models) that have been examined showed that macro-economic models generally perform well in the short to medium term (although they have several important limitations); micro-economic models do not perform credibly over time; and cohort processing models require data of individual vehicle ownership and income level which are not available in New Zealand.

The most effective approach for estimating vehicle ownership at a national level will therefore be a macro-economic model.

Data on the long-term trends in vehicle ownership in New Zealand over the last 25 years showed that:

- Over the period since 1970, regression analyses indicate that annual changes in car ownership (per person) are well "explained" by changes in GDP per person and car prices, plus a diminishing annual "time trend".
- The elasticity of annual changes in cars per person with respect to changes in GDP per person is estimated at 0.43, and with respect to changes in car prices is estimated at –0.17. These elasticities occur with little lag and should be regarded as "short run" estimates.
- The apparent "unexplained" time trend reduced rapidly over the period by an average 0.13% pa, to reach about 0.6% by 1996. This is relatively faster than the rate of reduction before 1970, which was about 0.08% pa over the period 1958 - 1970. This change may indicate an approach to saturation, although this is far from certain on the evidence available.

This analysis of past New Zealand vehicle-ownership data provides the basis for projection of future vehicle-ownership levels.

5.2 Basis for Forecasting Vehicle Ownership

Two critical elements in providing realistic vehicle-ownership forecasts are:

- Appropriate saturation level,
- Growth path to saturation.

5.2.1 Determining the Level of Saturation

In order to assist in determining an appropriate saturation level, we have examined recent trends in the US. However, in the four US states with the highest levels of per person-car ownership in 1986, there is little evidence of any significant slowing down in the growth rates, which could indicate an approach to saturation levels. US cross-sectional data from 1978 (Figure 2.6 in this report) show that, at relatively high income levels, around 0.95 cars are owned per adult.

In other countries, average income levels are considerably lower than in the US and data from these countries therefore cannot assist in determining a saturation level. Empirical data that are available from other countries are thus very limited for justifying any specific saturation levels. However common-sense and analogy with other consumer items would certainly indicate that a saturation level does exist and is a useful concept for modelling purposes.

At first thought, a plausible assessment is that the saturation level would occur when every person of driving age owns a car, with the exception of those who have a disability that prevents them from driving. However, the US data, which indicate more cars than driving licences in some states (Section 2.2 of this report), cast some doubt on whether this is really the saturation level of ownership. As cars get relatively cheaper to own, affluent people may well own more than one car, using different car types for different types of trips. (This is analogous to televisions, say, where many affluent households would have more televisions than people.) However, in cases where households have more cars than licence holders, not all the cars can be in use simultaneously and the marginal cars are unlikely to result in substantial increase in vehicle kilometres travelled. Hence for traffic planning purposes, estimating the "effective" saturation level on the above basis may be reasonable, while recognising that the physical saturation level may be higher.

Australian data indicate that about 5% of the population of driving age are unable to drive because of disabilities, mainly relating to advanced age and/or poor eyesight. Therefore a maximum "effective" saturation level might be taken as 0.95 cars per adult of driving age.

The UK DoT forecasts (1989) take 90% of the population in the 17-74 age group as the saturation level. In applying the cohort processing approach (van den Broecke 1988), the saturation level was taken as equal to the level of driver-licence holding. Provided this measure is available, it can give a good indication of how the saturation level is likely to grow in the future.

In practice, there will always be a proportion of the population who choose not to own a car (apart from reasons of disability, etc.). Based on UK experience, we estimate this proportion to be 5% of people of driving age. In addition, in urban areas car-ownership levels are likely to be lower because of the availability of public transport and the constraints on car use (car parking limitations, etc.). Based on the appraisal in Appendix A, we assume that this might reduce saturation levels by a further 5% of the people of driving age.

Thus plausible maximum and minimum values for saturation levels that have been derived are:

- Maximum: 0.95 "effective" cars/person of driving age.
- Minimum: 0.85 "effective" cars/person of driving age.

Table 5.1 shows the projected distribution of population in New Zealand by age group and the corresponding maximum and minimum saturation levels (assuming that the maximum driving age is retained at 15). It indicates gradual increases in saturation levels over time, as the proportion of children in the population decreases. The current saturation levels are in the range 0.66 cars/person (minimum) to 0.74 cars/person (maximum). By year 2031 these increase, due to changes in age distribution, to 0.70 cars/person (minimum) and 0.78 cars/person (maximum).

These levels may be usefully compared against US observed levels:

- The range of 0.67 - 0.79 cars/person is higher than that found in almost all US states in 1986 (Figure 2.5 in this report).
- The range of 0.85 - 0.95 cars/person of driving age covers the range of values found in the US among high income households for 1977-1978 (Figure 2.6).

Table 5.1 Population distribution and car ownership saturation levels for New Zealand.

	% Population by Age			Saturation Level	
Year	0-14	15-64	65+	Minimum[1]	Maximum[2]
1996	22.9	65.5	11.7	0.656	0.733
2001	22.5	65.7	11.8	0.659	0.736
2011	19.8	66.9	13.3	0.682	0.762
2021	18.0	65.0	17.0	0.697	0.779
2031	17.5	61.0	21.4	0.700	0.783

(Taken from Statistics NZ "Hot Off The Press" 13 May 1997
"New Zealand Population Projections – 1996 (Base)-2051")
Notes: [1] Minimum – 0.85 cars/person of age 15+
[2] Maximum – 0.95 cars/person of age 15+

5.2.2 Determining the Growth Path to Saturation

The second critical element in forecasting future vehicle-ownership levels is the growth path taken to reach the saturation level. The time scale taken will be influenced by:

- General level of economic activity (GDP/person),
- Real cost of motoring (both car purchase and car use),
- Household structure,
- Relative accessibility of private- and public-transport consumer taste.

The evidence from many other countries, and from the New Zealand data up to 1970, is that the "underlying time trend" has been the major factor determining trends in car ownership. Growth in cars/person has been more or less linear and showing little signs of tailing off towards saturation; and the relatively small variations from the linear trend line can be related to variations in income levels and motoring costs. This evidence would have suggested that the future growth path would have continued along the more-or-less linear trend for some years, assuming no dramatic change in income or motoring cost trends, until saturation was more closely approached.

However, the analysis of New Zealand data since the early 1970s suggests that the apparent "unexplained" time trend reduced rapidly over the period by an average 0.13% pa. This is relatively faster than the rate of reduction before 1970, which was about 0.08% pa over the period 1958 - 1970. With this reducing time trend, the effects from the trend of changes in GDP and car prices have become relatively more significant. This evidence would suggest, in terms of future growth projections, that:

- the underlying time trend in future may be much lower than historic trends, probably less than 1% and maybe close to zero, and
- economic factors are likely to have proportionally larger effects on the future growth pattern.

Our approach to determining the likely growth path to saturation has been to make a range of projections based on the regression analyses of more recent New Zealand data and a range of estimates for future trends in GDP/person, car prices, and time trends.

5.3 National Vehicle-Ownership Forecasts

The approach just described has been applied to develop a series of national forecasts of vehicle ownership per person in the following way:

1. Starting from the 1996 estimate of cars/person, from the MRC figures as adjusted (i.e. 0.493 cars/head).
2. Application of "low", "medium" and "high" growth projections based on the regression analyses that have been undertaken, and plausible ranges for trends in GDP/person, car prices, and annual time trends.

3. Constraint of the "minimum" and "maximum" saturation levels as defined in section 5.2.1 of this report. Table 5.2 shows the inputs to the three sets of growth projections.

Table 5.2 Inputs to growth projections: annual change (%) in growth.

Annual Change %	Low Growth	Medium Growth	High Growth
GDP/person	+ 0.5	+ 1.2	+ 2.0
Car Price	0.0	- 0.5	-1.0
Time Trend	0.6% in 1996, reducing by 0.1% pa until becoming 0% in 2001, and thereafter		

By way of comparison, over the 25-year period 1970 – 1995, GDP/person grew on average 1.2% per year, and car prices fell on average by 0.6% per year.

Based on these projections and the 1996 vehicle-ownership level, Table 5.3 and Figure 5.1 show the resulting car-ownership levels up to year 2031. Several comments should be made on these projections.

- The trendlines for the pre-1986 MRC data and the post-1986 MRC data are also shown on Figure 5.1 (labelled Linear (Pre-1986) and Linear (Post-1986) respectively). These show that the rate of growth in car ownership appears to have decreased markedly since 1986.
- The high growth estimate is between the two linear trendlines shown, and is very close to the trendline for the full 1970-1996 period (not shown). The high growth estimate represents an annual increase in real GDP/person of 2.0% and an annual decrease in real car prices of 1.0%. These are significantly above the average rates for the last 25 years.
- The medium growth estimate is based on an annual increase in real GDP/person of 1.2% and an annual decrease in real car prices of 0.6%. These are the average change rates for these two indicators over the last 25 years. This growth path falls below the post-1986 trendline as a result of the time trend falling to 0% from 2001.
- The low growth estimate represents 0.5% annual growth in GDP/person and no change in real car prices.

If growth were to continue according to the projections shown, then eventually the postulated saturation levels would be reached and surpassed. For instance, the "high growth" projection line reaches the minimum saturation level in about 2027 and the maximum saturation level in about 2040. In practice, therefore, a "tailing off" of growth for these projections might be expected before reaching the saturation levels. However, assuming that the high growth projection is associated with the maximum saturation level (which is an arguable assumption), then in every case any significant tailing off is likely to be beyond the 35-year period examined. It is therefore ignored for present forecasting purposes.

Figure 5.1 National estimates of vehicle ownership in New Zealand until year 2030.

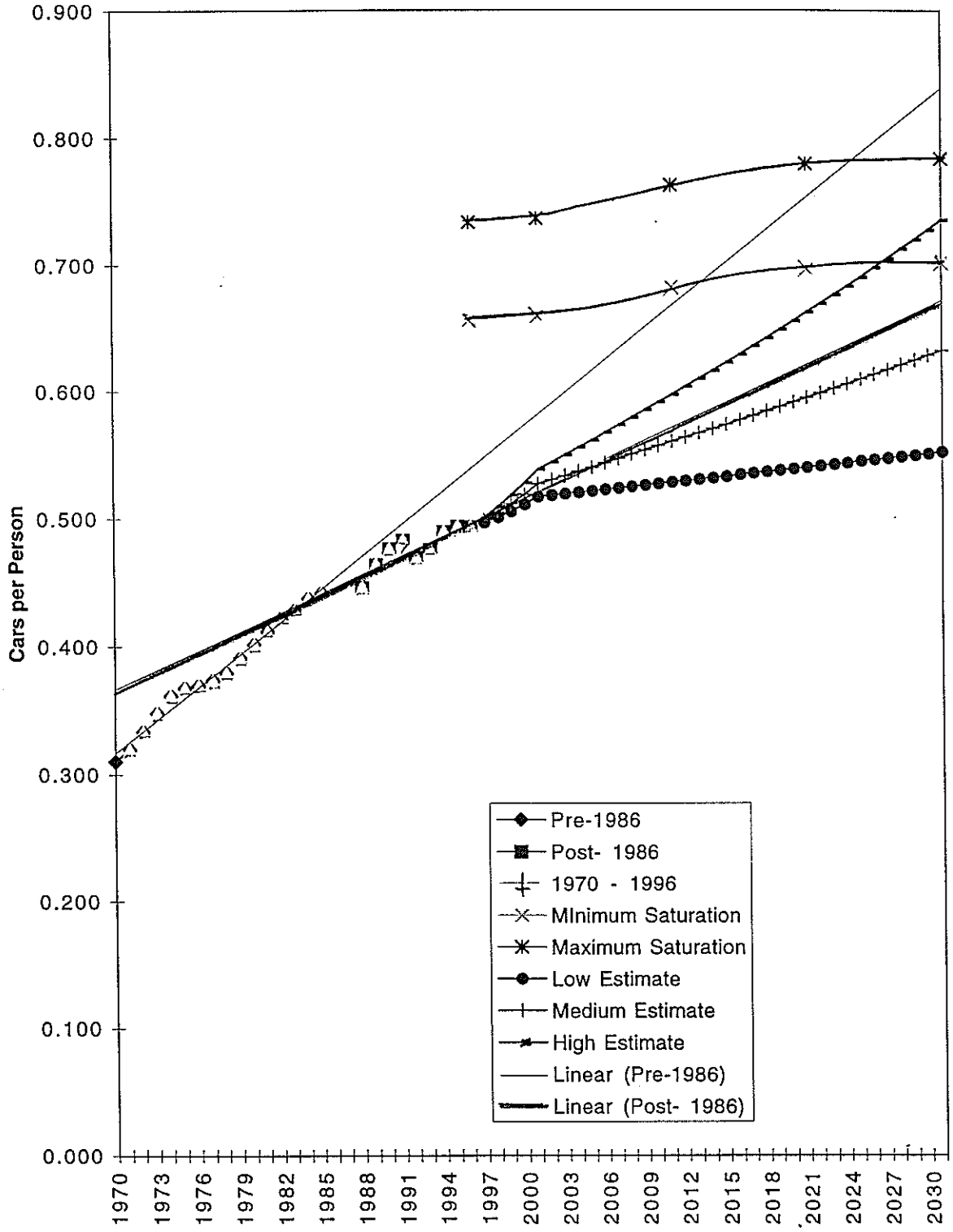


Table 5.3 National estimates of cars per person for period 1996 – 2031.

Year	Cars per Person		
	Low Growth	Medium Growth	High Growth
1996	0.493	0.493	0.493
2001	0.517	0.527	0.538
2006	0.522	0.543	0.567
2011	0.528	0.560	0.597
2016	0.534	0.577	0.629
2021	0.540	0.595	0.662
2026	0.546	0.613	0.697
2031	0.551	0.632	0.734
Average % Increase pa:			
96 - 01	0.9	1.3	1.8
01 onwards	0.2	0.6	1.0
Total % Increase on 1996 levels:			
2001	4.8	6.9	9.2
2006	6.0	10.2	15.0
2011	7.1	13.5	21.1
2016	8.3	17.0	27.5
2021	9.5	20.6	34.3
2026	10.6	24.3	41.4
2031	11.9	28.1	48.9

5.4 Regional Vehicle-Ownership Forecasts

The approach suggested for deriving regional forecasts of vehicle ownership that is consistent with the national forecasts is as follows:

1. Adjust the region's latest (1996) Census data on vehicles/person by the national adjustment factor from the Census statistics to MRC (adjusted) statistics to provide an estimate of the region's vehicles/person consistent with the national MRC data.

2. Locate the region's vehicles/person on the graph (Figure 5.1), and assume that the growth rate for the region follows the national projections, albeit displaced by a few years (according to the region's vehicle ownership relative to the national average figure).

However, as discussed in section 4.4.3 of this report, the relationship between the 1996 Census data and the corresponding MRC data is not consistent with that for 1986 and 1991. This throws some doubts on the reliability of the 1996 Census figures and the resulting adjustment factor. This needs to be resolved before the above method can be used with reasonable confidence.

5.5 Potential Areas For Further Research

Several issues have arisen in the project which have not been able to be fully addressed and resolved at this stage, but would warrant further work in order to provide improved national and regional forecasts with greater confidence. These include:

- Relationship between 1996 Census data and MRC data.
- International evidence on factors influencing vehicle ownership, in the light of New Zealand findings reported here. In particular, this should examine the most recent research relating to:

  - Saturation levels,

  - Use of cohort processing models and licence-holding data as means of determining levels of saturation and the approach to use,

  - Influence of economic variables on vehicle-ownership trends.

Appendix A

Effects of Public Transport Availability on Car Ownership

Appendix A
Effects of Public Transport Availability on Car Ownership

A1. Several attempts have been made to identify the impact of public transport availability and service levels on car ownership. Although there is a strong a priori case for assuming such a relationship, in practice any impact is small compared to the dominant factors of changes in habit, income and household structure. Few of the studies have therefore been able to isolate the impact with any precision.

A2. Most studies reported in the literature have been undertaken in the UK. The methodologies adopted included the analysis of aggregate data and disaggregate data as well as monitoring car ownership of a household panel.

A3. The aggregate studies of time-series data have all had considerable difficulty disentangling two effects. One is the impact of increases in car ownership (from whatever reason) on public transport use and a subsequent reduction in service levels. The other is the effect of a poor level of public transport provision on the need to purchase private vehicles with a consequent increase in car ownership.

A4. Other difficulties arise with the analysis of cross-sectional data at an aggregate level. Car ownership levels in urban areas are almost always lower than in suburban and rural areas. Part of this is because of better levels of public transport provision in urban areas but a significant factor in the denser conurbations is the general level of road congestion and difficulty in parking. Determining the relative weight of these various factors has so far proved intractable.

A5. Disaggregate studies have their own problems. These studies generally control for household structure and income effects, and then relate residual variations in car ownership to factors such as public transport accessibility. However, at least part of the correlation between car ownership and public transport provision may be due to households with lower vehicle ownership (for whatever reason) locating themselves near public transport routes. No study has so far successfully addressed this issue.

A6. One of the earliest studies was by Fairhurst (1975), who analysed aggregate data from the 1962 London Transportation Study. The model used relatively crude measures of public transport provision. Nevertheless the results showed that areas with higher levels of public transport provision generally had lower levels of car ownership, after allowance was made for income level and household size. However, such areas are generally also those with most congestion and the greatest difficulty in parking and these effects are undoubtedly compounded in the analysis with those arising from public transport alone. The analysis estimates an increase of 10% in public transport service frequencies would generate a 0.3% reduction in car ownership.

A7. A more detailed analysis (Mullen et al. 1976) was carried out as part of the Telford Transport Study (1976). This compared car-ownership rates in areas of a New Town (Telford) having widely varying levels of public transport. The results showed a pattern that has been subsequently observed several times, in which there is little effect on ownership levels for first cars but a significant effect on ownership levels for cars for housewives (generally second cars). Overall, the total impact of a good public transport system compared to a very poor public transport system was estimated at 0.06 vehicles per person.

A8. A similar study in a rural area (Edwards 1977) carried out at the same time showed very similar results. However, in absolute terms the overall effect on ownership levels was smaller, with the total impact estimated at 0.04 vehicles per person.

A9. The most disaggregate study carried out (Daly & Zachary 1977) compared groups of public transport employees who had free travel, with control groups who had to pay for their travel. The analysis controlled for the age, income, sex, and type of work of each individual and related residual differences in car ownership and use, to whether the individual had to pay his fare. The results showed that free travel would lead to a significant increase in public transport use, with an elasticity of around -0.3, consistent with general experience. However, the estimated reduction in car ownership was only around 0.01 vehicles per person.

A10. These results were summarised in a review paper by Jones & Tanner (1979), who also undertook a series of seven additional analyses. The results of the additional analyses were mixed. Statistical correlations between vehicle ownership and public transport use were estimated, but shed little light on causality. In one case (an analysis of Glasgow), the correlation was positive, a perverse result that the authors state ..."cannot be given a causal interpretation". Overall, conclusions were difficult to draw. At most, public transport provision affects car ownership by about 0.05 cars per person (or about 20%), mostly associated with second cars.

A11 Analysis of car ownership in Stockholm in 1970 (Algers 1973) showed rather larger elasticities of vehicle ownership with respect to public transport provision. However, analysis of data from Washington DC (Lerman & Ben Akiva 1976) produced elasticities that were very much smaller. It showed the effect of introducing a new service of very high quality in an area previously unserved was estimated as a reduction of about 0.05 vehicles per person, consistent with the UK results. Finally, a study in Amsterdam (Tanner 1981) found little impact of public transport service levels on first-car ownership but a significant effect on second-car ownership.

A12 The Amsterdam findings are similar to the results of analysis undertaken in Perth in 1980 as part of the "Perth 2000" study (Travers Morgan 1982). This analysis controlled for the effect of household structure and income levels, and then related vehicle ownership to accessibility as measured by the difference in public and private transport journey times (in practice a proxy variable was used). This analysis showed that the effect of public transport provision on car ownership steadily increased from the first car through the second car to the third car, in line with results obtained elsewhere.

A13. The most recent reported study (Goodwin 1986) analysed the effect of the low-fares policy pursued over a 10-year period in South Yorkshire. The analysis was based on the behaviour over a three-year period of a panel of 1,350 households. The analysis reports a mass of detailed data comparing changes in car ownership and bus use. However, it is difficult to determine an overall pattern, because of the lack of a control group. Although there was a shift from car to public transport in the area studied, it is unclear how much this was caused by external economic circumstances and how much was due to the low-fares policy. There are little data by which the impact of public transport provision on car ownership can be assessed.

A14. In summary, a number of studies have been undertaken, using a variety of methods and data, which have produced limited reliable results. There is general agreement that the level of public transport provision has little impact on first-car ownership but rather more on second- and third-car ownership. The overall impact is localised and relatively small, probably 0.05 vehicles per person at most, or 10-20% of current ownership levels. As this is significantly less than variations in ownership caused by household structure and income, the impact has proved difficult to measure with any precision in practice.

A15. There is no doubt that in major conurbations such as London, Tokyo and New York, vehicle ownership is significantly below that in smaller cities and suburbs. However, much of this is due to physical constraints on car ownership and use, particularly congestion and parking problems. As an extreme example, the availability of off-street parking in Tokyo must be demonstrated before a new car can be registered.

A16. Such problems do not exist in New Zealand cities to the same extent, nor are likely to for the foreseeable future. Thus the impact of public transport provision on car-ownership levels in New Zealand cities is probably equivalent at most to around 0.05 vehicles per person, based on UK, European and Australian analysis. Whether this impact will be maintained as saturation approaches can only be a matter of conjecture at this stage.

Appendix B

Car Ownership per Person by State for United States

Appendix B
Car Ownership per Person by State for United States

	1986	1984	1982	1980	1978	1976	1974	1972	1970
US	0.563	0.551	0.539	0.545	0.527	0.504	0.494	0.463	0.437
Ala	0.596	0.581	0.570	0.544	0.540	0.525	0.521	0.494	0.451
Alaska	0.406	0.468	0.429	0.390	0.424	0.406	0.363	0.309	0.307
Ariz	0.501	0.551	0.560	0.487	0.464	0.460	0.499	0.484	0.463
Ark	0.396	0.395	0.490	0.445	0.442	0.409	0.390	0.363	0.376
Calif	0.570	0.575	0.540	0.543	0.525	0.516	0.525	0.513	0.492
Colo	0.620	0.636	0.612	0.610	0.621	0.566	0.558	0.528	0.494
Conn	0.745	0.693	0.617	0.663	0.634	0.600	0.573	0.552	0.504
Del	0.605	0.589	0.548	0.547	0.528	0.497	0.491	0.470	0.476
DC	0.524	0.345	0.418	0.373	0.360	0.352	0.336	0.321	0.304
Fla	0.697	0.700	0.632	0.660	0.569	0.535	0.576	0.549	0.521
Ga	0.553	0.549	0.526	0.556	0.546	0.495	0.534	0.493	0.449
Hawaii	0.555	0.551	0.537	0.535	0.494	0.455	0.502	0.473	0.461
Idaho	0.527	0.529	0.552	0.507	0.514	0.499	0.519	0.501	0.459
Ill	0.531	0.521	0.561	0.660	0.517	0.482	0.469	0.436	0.409
Ind	0.551	0.518	0.527	0.536	0.519	0.483	0.487	0.436	0.441
Iowa	0.697	0.612	0.590	0.602	0.580	0.403	0.539	0.507	0.489
Kans	0.606	0.584	0.576	0.590	0.577	0.547	0.572	0.541	0.498
Ky	0.477	0.488	0.492	0.501	0.502	0.493	0.482	0.454	0.425
La	0.462	0.457	0.456	0.470	0.435	0.438	0.435	0.404	0.373
Maine	0.546	0.504	0.461	0.472	0.519	0.481	0.470	0.436	0.407
Md	0.621	0.615	0.566	0.563	0.535	0.514	0.487	0.449	0.413
Mass	0.560	0.587	0.570	0.580	0.560	0.495	0.474	0.441	0.404
Mich	0.630	0.555	0.543	0.566	0.560	0.521	0.501	0.473	0.439
Minn	0.651	0.588	0.566	0.603	0.537	0.500	0.500	0.484	0.459
Miss	0.524	0.459	0.470	0.463	0.438	0.421	0.414	0.399	0.369
Mo	0.523	0.510	0.503	0.499	0.481	0.460	0.447	0.426	0.403
Mont	0.466	0.638	0.538	0.747	0.588	0.498	0.498	0.522	0.448
Nebr	0.527	0.516	0.497	0.557	0.554	0.547	0.523	0.513	0.476
Nev	0.521	0.595	0.599	0.528	0.599	0.549	0.581	0.545	0.536
NH	0.832	0.729	0.695	0.590	0.554	0.494	0.485	0.471	0.409
NJ	0.581	0.591	0.561	0.587	0.556	0.529	0.522	0.472	0.446
NMex	0.495	0.575	0.506	0.523	0.484	0.485	0.458	0.464	0.443
NY	0.461	0.428	0.405	0.408	0.388	0.382	0.372	0.347	0.327
NC	0.523	0.575	0.573	0.594	0.567	0.529	0.514	0.478	0.434
NDak	0.554	0.577	0.569	0.560	0.539	0.524	0.505	0.460	0.430
Ohio	0.648	0.606	0.592	0.579	0.605	0.609	0.559	0.511	0.496
Okla	0.579	0.529	0.563	0.610	0.545	0.516	0.515	0.499	0.473
Oreg	0.579	0.556	0.586	0.575	0.560	0.575	0.601	0.559	0.529
Pa	0.503	0.493	0.507	0.490	0.581	0.576	0.504	0.459	0.427
RI	0.530	0.545	0.550	0.542	0.632	0.535	0.540	0.487	0.454
SC	0.508	0.499	0.470	0.494	0.499	0.503	0.473	0.443	0.423
SDak	0.606	0.565	0.548	0.542	0.530	0.502	0.491	0.461	0.435
Tenn	0.639	0.636	0.626	0.517	0.546	0.502	0.484	0.445	0.415
Tex	0.516	0.521	0.524	0.519	0.545	0.493	0.499	0.472	0.456
Utah	0.440	0.465	0.459	0.470	0.470	0.476	0.464	0.474	0.449
Vt	0.582	0.562	0.533	0.508	0.532	0.493	0.493	0.464	0.425
Va	0.663	0.604	0.600	0.572	0.537	0.551	0.478	0.449	0.403
Wash	0.594	0.553	0.567	0.559	0.572	0.532	0.523	0.494	0.471
WVa	0.448	0.474	0.506	0.497	0.414	0.404	0.384	0.372	0.390
Wis	0.528	0.545	0.538	0.538	0.488	0.479	0.468	0.438	0.419
Wyo	0.564	0.571	0.608	0.614	0.520	0.534	0.529	0.501	0.473

Source : US Federal Highway Administration ' Highway Statistics '

Appendix C

Analysis of Effects of Income Levels on Car Ownership in New Zealand

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Analysis of Effects of Income Levels on Car Ownership in New Zealand

The rate of growth of car ownership in New Zealand from 1973 onwards is not apparently related to the general level of economic activity, expressed in terms of GDP per person. Car ownership levels continued to rise steadily against static or declining real incomes. Although income is undoubtedly a key determinant of the level of car ownership, a variety of other influencing factors have been identified, including:

- the real cost of motoring
- household structure
- relatively accessibility of highway and public transport
- consumer taste

The precise contribution of each of these factors to the level of car ownership is not clear. However, it is likely that the use of aggregated data has masked a change in the distribution of income as a result of socio-demographic changes. This has led to the growth in average income (expressed as GDP per person) understating the increase in affluence of certain income-earning groups which are postulated as having a greater propensity to own a car.

We have investigated this last point by examining the distribution of income (in NZ$1976) for Hutt City from 1976 and 1986 Census data.

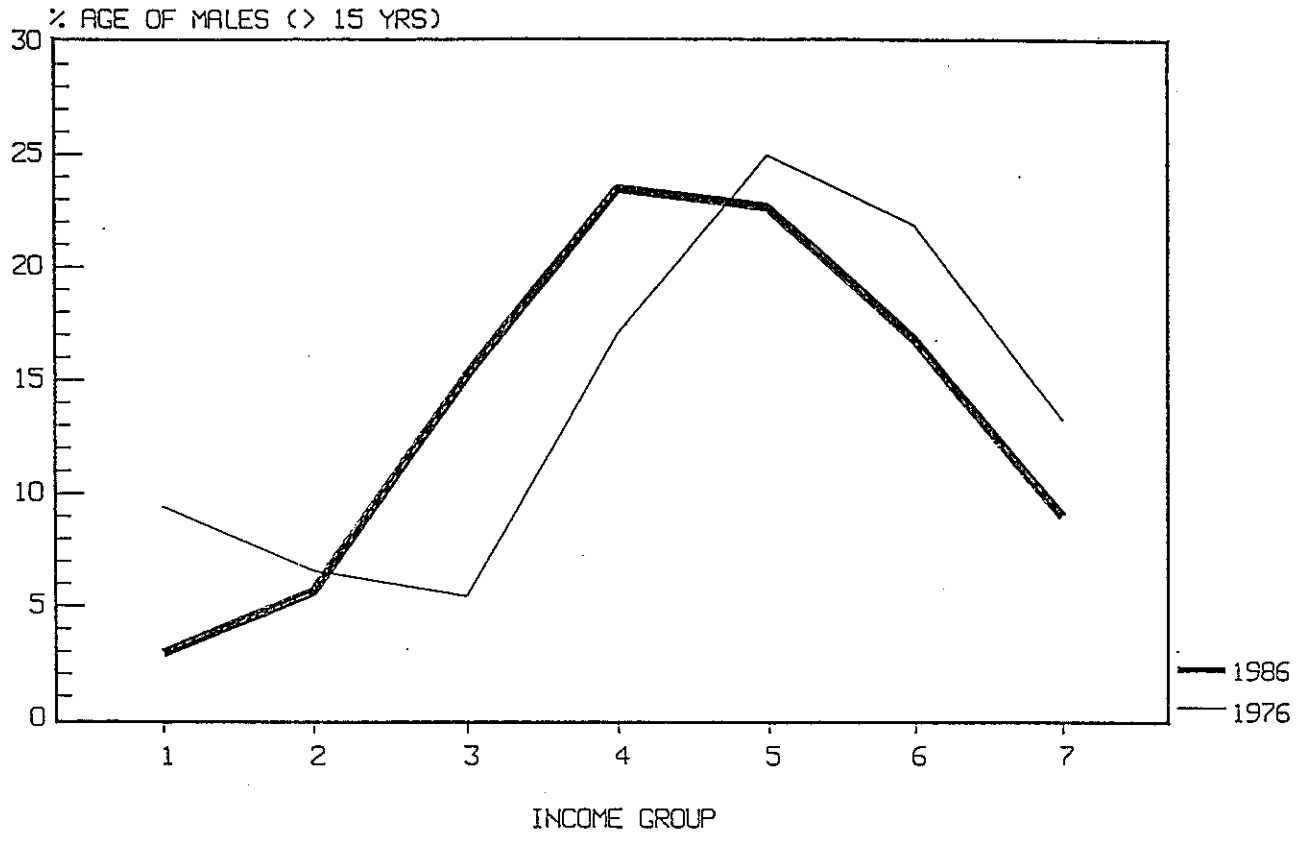
This shows:

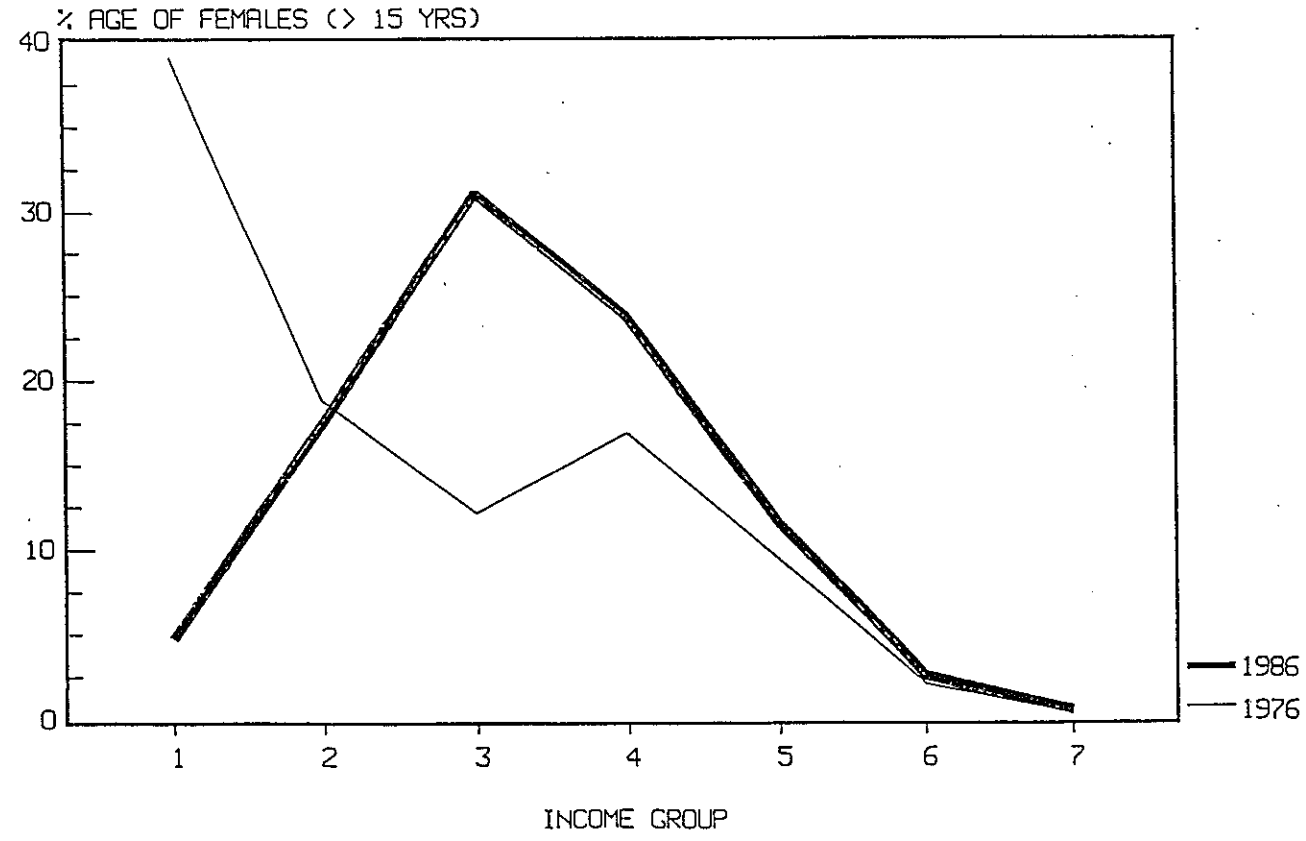
- real average income (male and female) increased slightly from $3,665 in 1976 to $3,840 in 1986, or + 4.8%;
- real average income (males) decreased from $5,542 in 1976 to $5,017 in 1986, or -9.5%;
- real average income (females) increased from $1,880 in 1976 to $2,755 in 1986, or + 46.5%.

The distribution of income for the two years is shown in Figure C1. The figures indicate the significant increase of the Lower Hutt City population in Income Groups 3 and 4 (males and females) which are postulated as having a greater propensity to own a car. We could postulate that people who have moved up into Income Groups 3 and 4 are now in a position to afford a car. However those (mainly males) who have moved down into Income Groups 3 and 4 are unlikely to relinquish their cars. Hence, the slight increase in average real incomes (males and females) from 1976 to 1986 has understated the increase in affluence of certain income groups which are postulated as having a greater propensity to own a car.

This analysis is certainly not conclusive. It does, however, show that the use of an aggregate figure such as GDP per person may only be a partial measure of the level of economic activity.

Figure C1 Change in income group distribution for Lower Hutt City, New Zealand.
Source: NZ Census data





Appendix D

Statistics & Related Factors of New Zealand Vehicle Ownership

Appendix D
Statistics & Related Factors of New Zealand Vehicle Ownership

1. Introduction

Any forecasts of future vehicle ownership need to be based on good information on present/recent ownership levels and an understanding of past trends. This Appendix therefore derives estimates of present and past vehicle ownership in New Zealand and presents information on some of the factors expected to have influenced the past trends.

It was originally expected that a time series of past vehicle ownership in New Zealand could be taken directly from published statistics. However, this proved not to be the case, particularly because of changes in the last few years in the "standard" method of recording the number of motor vehicles registered. Hence considerable investigations had to be made in order to estimate a consistent and realistic time series of vehicle ownership at the national level. These investigations are summarised here and a "best" time series derived.

The remainder of this Appendix is structured as follows:

- Section D2 reviews the potential sources of national motor vehicle statistics.
- Section D3 describes the basis adopted in the project to derive a consistent national series of motor vehicle registrations, and presents the results.
- Section D4 presents trend information on factors expected to have influenced levels of motor vehicle ownership.

2. NZ Motor Vehicle Statistics

2.1 Potential Sources

NZ vehicle registrations are maintained by the Motor Registration Centre (MRC), a division of the Land Transport Safety Authority (LTSA), under contract to the Ministry of Transport. Three time series, which have been derived from the MRC data, are readily available:

- Tables of "Licensed Motor Vehicles" in the transport section of the NZ Yearbooks.
- Tables of "Vehicles Registered", in "Motor Accidents in New Zealand", a report produced annually by the LTSA.
- Tables of vehicles licensed by quarter prior to 1987, and by month after 1987, held by Statistics NZ.

2.2 NZ Yearbooks Series

This series is based on the MRC March Quarterly Return. It represents the number of motor vehicles actually licensed at 31 March each year (but refer later discussion on this definition). It is broken down into the following motor vehicle categories:

Cars
Rental cars
Private taxicabs
Goods service vehicles
Omnibuses
Public taxicabs
Service coaches
Motor cycles
Power cycles (mopeds).

Published data is available from 1951.

Table D1 shows the NZ Yearbooks' statistics for licensed motor vehicles in New Zealand from 1951 to 1996 (at 31 March in each case).

The series of numbers appears to be sensibly consistent from 1951 to 1986. In 1987 no figures were provided due to the introduction of a new spread relicensing system. The series was continued in 1988. However, the 1988 figure is some 10% lower than the 1986 figure: this is obviously unrealistic, and prompted further investigations about the compilation of the figures.

Discussions with MRC and LTSA staff provided the following information on the Yearbook data:

* **Prior to 1986**
- Motor Registration had a manual recording system.
- All motor vehicles were relicensed annually at the same time of the year.
- Deregistered vehicles were only deleted from the record of licensed vehicles once a year, following the end of the June quarter. The March quarterly return therefore included vehicles scrapped (deregistered) during the preceeding 9 months.
- The statistics provided for the New Zealand Yearbooks represented the total number of licensed vehicles at the end of the March quarter - that is, all vehicles licensed at the end of the March quarter plus any other vehicles which were licensed from 1 July for which licences may have subsequently been deregistered.

* **From 1986**

- A computerised recording system was installed in 1987.
- The statistics provided after 1986 represent the number of current licensed vehicles at the date of reporting.
- Vehicles which are deregistered are removed from the computer records immediately and therefore from the number of licensed vehicles at the date of reporting.
- The new computer system coincided with the introduction of the new spread relicensing system. The new system had licensing periods of both 6 months and 12 months, and licence expiry dates spread throughout the year.
- The change to reporting statistics `as at' a certain date rather than `for the year ended', and the new spread relicensing system meant that a significant proportion of vehicles were not recorded in the annual statistics because their licence was paid late after the due date.

We conclude from this that:

- The motor vehicle statistics prior to 1987 were an over-estimate of the number of vehicles licensed at any one time, due to deregistered vehicles not being removed from the totals.
- The motor vehicle statistics after 1987 represent the number of vehicles for which licences were strictly valid at any one time, not allowing for any late re-licensing. These should be added in to reflect the total `active' vehicles at any one time.

2.3 LTSA Series

This series, which is published by the LTSA in its "Motor Accidents in New Zealand" publication (previously produced by Ministry of Transport (MOT) Land Transport Division), was originally based on the MRC December quarterly return, and represented the numbers of vehicles registered at 31 December each year.

It differs from the Yearbook series in two ways:

- the LTSA series includes vehicle categories not included in the Yearbook series: Exempt Vehicles, Tractors, Trade Plates, and Caravans.

- it includes 6 months of scrapped vehicles, whereas the Yearbook series includes 9 months.

Since the new licensing system was introduced in 1987 the LTSA figures have been estimated using a simple spreadsheet model rather than based directly on the MRC returns. The model is based on: the number of new

vehicle registrations plus a fixed proportion of the number of licensed vehicles from the previous year. The latter assumes a fixed scrappage rate of around 5% per annum.

The LTSA figures for total motor vehicles from 1951 are included in Table D.1.

2.4 Statistics NZ MRC Database

Statistics NZ maintains a database of licensed motor vehicles by vehicle type, based on the MRC returns, going back to 1970.

The data held is in two distinct time series:

- 1970 to 1986: number of licensed vehicles by type for each quarter (March, June, September, December). As with the Yearbook series prior to 1987, the quarterly returns include scrapped vehicles and is an over-estimate of 'active vehicles'. Using the September quarter will minimise this as scrapped vehicles (deregistered) were removed at the end of the June quarter each year.

- 1988 onwards: number of vehicles licensed by type at the end of each month - that is, the number of currently licensed vehicles. Vehicles relicensed late are therefore excluded. This series is therefore an under-estimate of 'active' vehicles.

The Statistics NZ September quarter figures are shown in Table D.1.

2.5 Best Database

Having reviewed the three main sources of time series data on NZ motor vehicle ownership, it was decided to use the Statistics NZ data (September quarter) as the basis from which to derive a consistent time series.

This decision was based on the following considerations:

- All three time series are based on the MRC data, and would be suitable as the basis for a historical time series.

- The Yearbook data, which reports licensed vehicles at the end of March each year, includes prior to 1987 a higher proportion of scrapped vehicles than does the Statistics data: it will therefore be a less accurate representation of active vehicles than the Statistics data.

- The LTSA figures will also be a less accurate representation of active vehicles than the Statistics data: they represent licensed vehicles at the end of December each year; and, since 1986, have been estimated using a simple spreadsheet model. The LTSA is reviewing its

TABLE D.1: NEW ZEALAND VEHICLE OWNERSHIP DATA (000)

Year	NZ Yearbook Licensed Motor Vehicles as at 31 March					NZ Statistics Licensed Motor Vehicles-Sept Quarter					LTSA
	Cars	Motorcycles	Goods	Other	Total	Cars	Mcycs	Goods	Buses	Total	Lic Veh to 31/12
1951	252.5	21.0	84.9	6.9	365.4						447.1
1952	282.0	26.7	95.2	7.0	410.9						494.2
1953	307.3	29.2	101.0	7.2	444.7						513.7
1954	325.3	29.7	103.0	7.3	465.3						553.5
1955	358.1	30.4	107.3	7.5	503.2						601.1
1956	395.5	28.8	115.2	7.7	547.1						638.3
1957	427.0	31.2	121.5	7.8	587.4						672.6
1958	464.6	33.9	115.3	7.8	621.7						702.9
1959	482.6	36.2	117.7	7.3	643.8						728.2
1960	504.8	36.8	119.4	7.2	668.3						762.7
1961	526.3	39.3	124.4	7.2	697.2						806.3
1962	555.8	44.4	130.2	7.5	737.8						844.1
1963	586.8	45.7	133.0	7.9	773.3						899.4
1964	633.3	46.9	138.3	7.6	826.1						963.9
1965	691.5	50.1	153.8	8.8	904.2						1,013.8
1966	727.7	49.7	163.4	8.2	949.0						1,060.2
1967	784.1	49.6	163.0	7.7	1,004.5						1,087.6
1968	810.9	48.4	164.7	7.7	1,031.7						1,114.7
1969	836.6	47.9	167.0	7.9	1,059.3						1,148.7
1970	865.2	48.0	171.5	7.8	1,092.4	874.1	40.3	169.4	3.1	1086.8	1,208.7
1971	911.9	53.1	181.8	7.4	1,154.1	913.3	47.7	175.8	3.0	1139.9	1,272.4
1972	959.5	62.9	190.6	7.3	1,220.3	968.0	55.8	180.3	3.0	1207.0	1,349.1
1973	1,025.0	72.4	194.7	7.3	1,299.4	1029.5	63.6	187.3	3.0	1283.4	1,438.8
1974	1,083.8	87.1	200.1	7.3	1,378.4	1092.1	76.3	192.9	3.0	1364.4	1,515.3
1975	1,134.9	93.7	206.8	7.6	1,442.9	1134.0	83.4	194.6	3.1	1415.2	1,574.5
1976	1,177.4	103.0	211.2	7.6	1,499.2	1159.6	88.0	216.4	3.1	1467.2	1,631.3
1977	1,205.9	107.0	232.2	7.7	1,552.8	1181.9	85.5	221.3	3.2	1491.9	1,642.8
1978	1,221.2	105.8	236.7	7.7	1,571.3	1203.5	82.7	230.4	3.2	1519.9	1,675.1
1979	1,250.2	106.5	247.9	7.7	1,612.3	1239.9	95.8	235.6	3.2	1574.5	1,732.9
1980	1,289.6	125.1	253.6	7.9	1,676.2	1273.0	108.1	245.1	3.4	1629.6	1,789.4
1981	1,325.4	138.5	264.5	8.0	1,736.4	1308.5	113.5	257.3	3.3	1682.6	1,846.1
1982	1,366.7	145.9	281.2	7.9	1,801.8	1347.1	114.3	262.4	3.7	1727.4	1,896.3
1983	1,401.2	145.4	288.0	7.5	1,842.2	1378.3	112.6	270.9	4.0	1765.9	1,921.5
1984	1,439.2	142.5	294.0	7.9	1,883.6	1427.1	108.0	275.1	4.5	1814.8	1,969.3
1985	1,491.9	138.9	299.8	7.6	1,938.2	1454.8	105.2	283.5	4.9	1848.4	1,995.0
1986	1,523.2	134.8	306.0	8.1	1,972.1						2,010.1
1987											2,030.6
1988	1,382.3	98.3	289.2	11.0	1,780.8	1404.3	91.8	292.5	8.1	1796.8	2,045.4
1989	1,438.7	90.7	289.2	11.1	1,829.7	1464.8	82.4	295.3	8.4	1850.9	2,108.4
1990	1,497.7	82.3	295.3	11.2	1,886.5	1511.3	72.1	300.5	7.8	1891.8	2,197.7
1991	1,548.1	74.8	301.2	10.8	1,934.8	1549.9	69.0	312.1	7.2	1938.2	2,220.1
1992	1,551.4	66.7	309.3	10.9	1,938.2	1524.4	55.5	313.4	7.8	1901.0	2,227.1
1993	1,571.8	61.2	322.4	12.0	1,967.4	1562.8	52.9	334.3	8.3	1958.4	2,243.8
1994	1,611.8	59.1	340.3	12.7	2,023.9	1626.9	52.0	353.9	8.8	2041.7	2,289.3
1995	1,660.5	55.9	355.8	13.6	2,085.8	1662.3	46.7	359.6	9.1	2077.8	2,354.6
1996	1,650.1	49.3	342.2	15.0	2,056.6	1698.4	43.5	357.7	9.7	2109.3	

Note: Statistics NZ Figures for 1986 unreliable, and Statistics & Yearbook figures for 1987 unavailable, due to the introduction of the new relicensing system.

3. Project Estimates of Motor Vehicle Ownership in New Zealand

3.1 Method

For purposes of this project, we required a time series on a consistent basis of annual figures for the numbers of `active' motor vehicles (cars, motorcycles) in New Zealand. As detailed above, it was decided to use the September quarter data from the Statistics NZ MRC database as the basis for this time series. However, several issues had to be addressed in developing the time series, and these are discussed below.

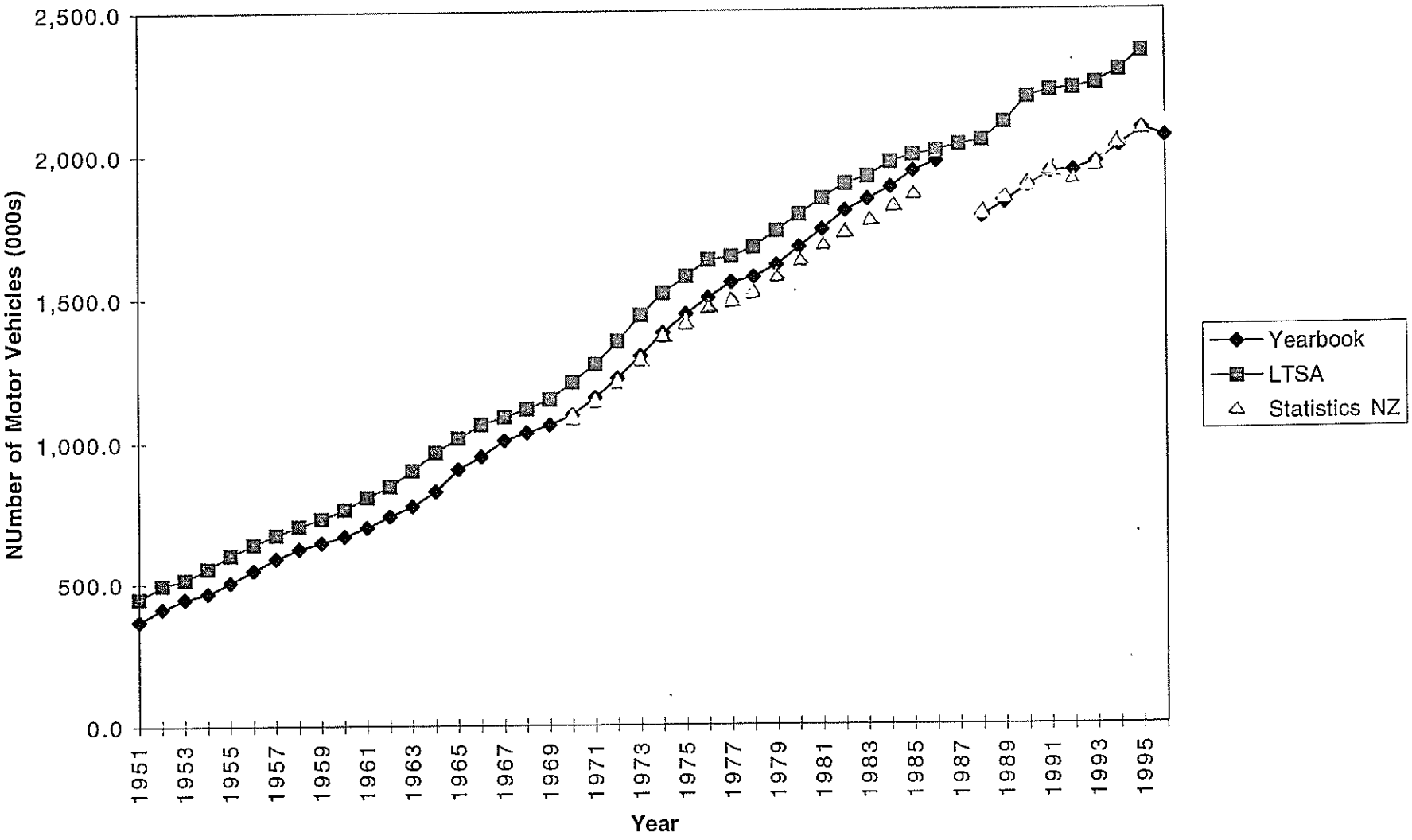
- *Scrapped Vehicles*
  Prior to the introduction of the computer based relicensing system in 1986 vehicles which were scrapped during the year continued to be counted as being licensed until the end of June, at which time all deregistered vehicles were removed from the records. Thus, the MRC based records always included some 'inactive' vehicles, with the number of these increasing during the year from July to June.

  Analysis conducted by the Land Transport Division of the MOT in the early 1990s concluded that the proportion of scrapped vehicles ranged from between 3% pa and 6% pa of licensed vehicles for the period 1970 to 1992, averaging out to 4.4% pa over that period. Using the September quarter figures minimises the number of scrapped vehicles being counted as 'active'; however, there still will be a small number of scrapped vehicles included in Statistics numbers. The pre-1986 figures have therefore been adjusted downwards by 1% to reflect this (1% being one quarter of the average annual proportion).

- *Late Relicensing*
  Prior to 1986 all vehicles were counted by MRC as being licensed, unless they had actually been deregistered. This meant that vehicles which were relicensed late were also counted in the total of licensed vehicles. However, since 1986 the figures released by MRC to Statistics NZ have been the actual number of vehicles with current licences. This means that the post-1986 figures are an under-estimate of 'active' vehicles as they do not include late registrations.

  An analysis by the MOT Land Transport Division in 1992 over a 6 month period concluded that about 8% of active vehicles were not relicensed at any one time. We analysed two sets of motor vehicle licensing data, one which was gathered by the MOT and one by the LTSA. This analysis found that the number of all 'active' vehicles unlicensed at any one time was 4% and 5.5% of the total licensed vehicles (this analysis assumed that all vehicles relicensed within 12 months of their anniversary date were 'active'). We have therefore

Figure D1 Licensed Motor Vehicles TIme Series



increased the Statistics post-1986 data by 5% to account for late registrations.

- *Semi-permanently Unlicensed*
  We have not made any adjustments for vehicles which are unlicensed for more than 12 months, although it could be argued these should be made. The MOT's broad estimates are that these are about 1-2% of all vehicles (reliable data are not available).

- *Vehicle Categories*
  Vehicle categories have changed over time. However, the Statistics NZ data is sufficiently detailed so that this variation has been able to be accounted for in the vehicle totals.

3.2 Results

After applying the above adjustments to each vehicle type, Table D.2 and D.3 shows our estimates of annual motor vehicle ownership in NZ by vehicle type since 1970. Figure D.2 shows this data graphically.

The adjustments have involved:

- A reduction in the Statistics September figures pre-1986 of 1%.
- An increase in the Statistics September figures post-1986 of 5%.

The result is a much more plausible pattern of change between 1986 and 1988 than in the original figures.

Key features of the results include:

- Total of 2.215 million motor vehicles at September 1996.
- This total comprises 80.5% cars, 2.1% motorcycles, 16.9% goods, and 0.5% buses.
- Numbers of cars and good vehicles have increased almost every year throughout this period. Apart from the 1986/87 'blimp', which has been resolved partially by the adjustments made, the only recent exception to this steady upward trend was in 1992 when the number of cars dropped slightly for the first time in 20 years.
- Numbers of motorcycles increased rapidly in the 1970's, peaked in the mid-1980's and has since decreased by almost half.

Table D.3 derives statistics for cars and motorcycles per person, while Figure D.3 shows this information graphically. Notable features of the figures for cars are:

- Latest (1996) car ownership is 0.493/person (compared with 0.470 on unadjusted statistics).

- This compares to a car ownership rate of 0.310/person in 1970, 26 years ago: this is an absolute increase of 59% and an average annual increase of 1.8%.
- Car ownership has continued to grow since the change in the licensing system, with the car ownership rate increasing from 0.445/person in 1988 to 0.493/person in 1996; an absolute increase of 10.8% and an average annual increase of 1.3%. A relatively rapid growth from 1988 to 1991 of 2.7% per year was followed by a decline of 2.7% in 1992; however, the upward trend has continued with an average annual increase of 1.3% from 1992 to 1996.

TABLE D.2: ESTIMATES OF NEW ZEALAND MOTOR VEHICLE OWNERSHIP 1970-1995 (000)

Year	Licensed Vehicles[1] Sept Quarter	Adjustment Factor	BAH Estimate
1970	1086.8	0.99	1,075.9
1971	1139.9	0.99	1,128.5
1972	1207.0	0.99	1,195.0
1973	1283.4	0.99	1,270.6
1974	1364.4	0.99	1,350.7
1975	1415.2	0.99	1,401.0
1976	1467.2	0.99	1,452.5
1977	1491.9	0.99	1,476.9
1978	1519.9	0.99	1,504.7
1979	1574.5	0.99	1,558.7
1980	1629.6	0.99	1,613.3
1981	1682.6	0.99	1,665.8
1982	1727.4	0.99	1,710.1
1983	1765.9	0.99	1,748.2
1984	1814.8	0.99	1,796.6
1985	1848.4	0.99	1,829.9
1986	1859.3	0.99	1,840.7
1987	1891.4	0.99	1,872.5
1988	1796.8	1.05	1,886.7
1989	1850.9	1.05	1,943.4
1990	1891.8	1.05	1,986.3
1991	1938.2	1.05	2,035.1
1992	1901.0	1.05	1,996.1
1993	1958.4	1.05	2,056.3
1994	2041.7	1.05	2,143.8
1995	2077.8	1.05	2,181.6
1996	2109.3	1.05	2,214.8

Notes: (1) NZ Statistics September Quarter (Table D.1)

(2) Figures for 1986 and1987 estimated

TABLE D.3: NEW ZEALAND MOTOR VEHICLE OWNERSHIP 1970-1996

Year	Cars (000)	Motorcycles (000)	Goods (000)	Buses (000)	Total (000)	Population Mean (000)	Cars Per Person	Motor-Cycles Per Head
1970	865.3	39.9	167.7	3.0	1075.9	2788.9	0.310	0.014
1971	904.1	47.2	174.1	3.0	1128.5	2831.2	0.319	0.017
1972	958.3	55.2	178.5	3.0	1195.0	2876.0	0.333	0.019
1973	1019.2	63.0	185.4	2.9	1270.6	2931.3	0.348	0.021
1974	1081.2	75.6	190.9	3.0	1350.7	2993.6	0.361	0.025
1975	1122.7	82.6	192.7	3.1	1401.0	3057.8	0.367	0.027
1976	1148.0	87.1	214.2	3.1	1452.5	3111.3	0.369	0.028
1977	1170.1	84.7	219.1	3.1	1476.9	3136.2	0.373	0.027
1978	1191.5	81.9	228.1	3.2	1504.7	3143.5	0.379	0.026
1979	1227.5	94.8	233.2	3.2	1558.7	3143.1	0.391	0.030
1980	1260.3	107.0	242.6	3.4	1613.3	3138.0	0.402	0.034
1981	1295.4	112.3	254.8	3.3	1665.8	3146.7	0.412	0.036
1982	1333.6	113.1	259.8	3.7	1710.1	3161.2	0.422	0.036
1983	1364.6	111.4	268.2	4.0	1748.2	3189.5	0.428	0.035
1984	1412.8	107.0	272.4	4.5	1796.6	3230.6	0.437	0.033
1985	1440.3	104.1	280.6	4.9	1829.9	3259.3	0.442	0.032
1986	1451.7	105.2	278.1	5.8	1840.7	3273.3	0.444	0.032
1987	1478.4	102.7	285.3	6.1	1872.5	3281.6	0.451	0.031
1988	1474.6	96.4	307.2	8.5	1886.7	3310.2	0.445	0.029
1989	1538.0	86.5	310.1	8.8	1943.4	3318.3	0.463	0.026
1990	1586.8	75.7	315.5	8.2	1986.3	3336.5	0.476	0.023
1991	1627.4	72.5	327.7	7.5	2035.1	3373.1	0.482	0.021
1992	1600.6	58.2	329.1	8.2	1996.1	3415.8	0.469	0.017
1993	1641.0	55.6	351.0	8.7	2056.3	3452.0	0.475	0.016
1994	1708.3	54.6	371.6	9.2	2143.8	3491.1	0.489	0.016
1995	1745.5	49.0	377.6	9.6	2181.6	3539.3	0.493	0.014
1996	1783.3	45.6	375.6	10.1	2214.8	3618.3	0.493	0.013

Note: Figures for 1986 and1987 estimated

Figure D2 Vehicle ownership in New Zealand, for period 1970-1996.

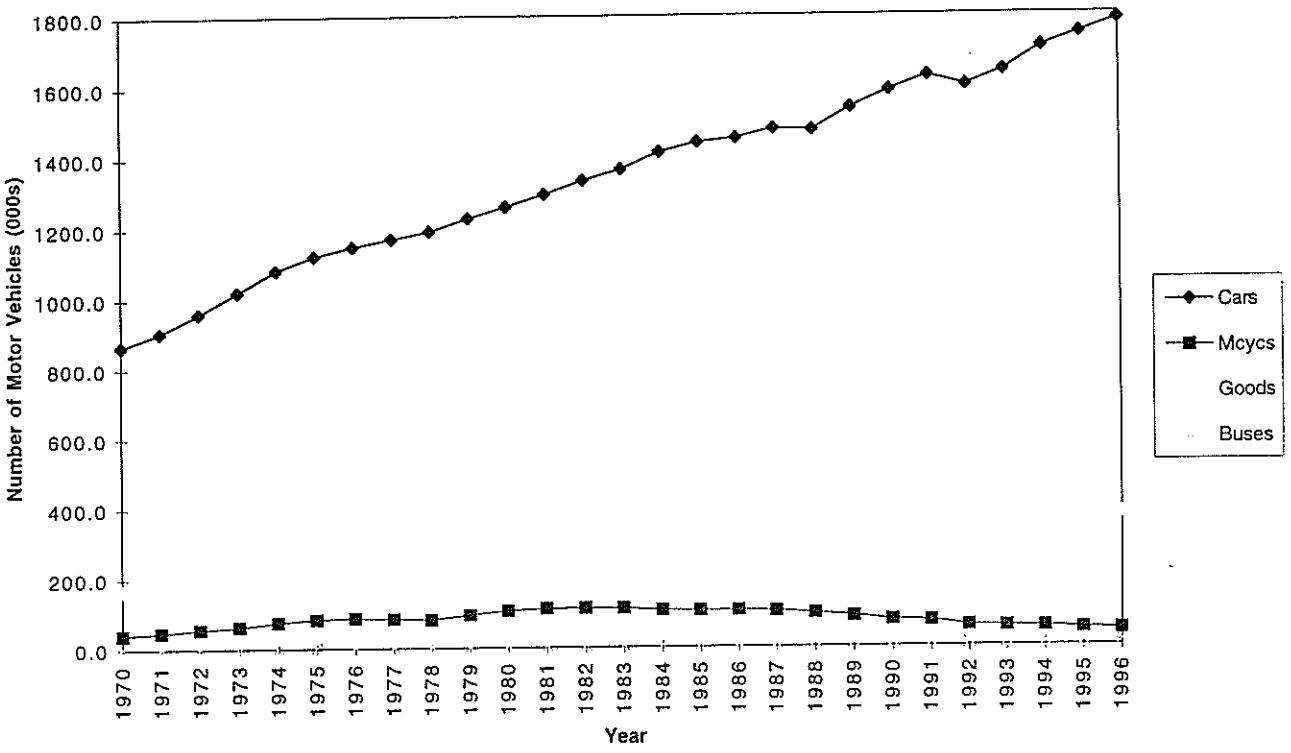


Figure D3 Vehicle ownership per person in New Zealand, for period 1970-1996.

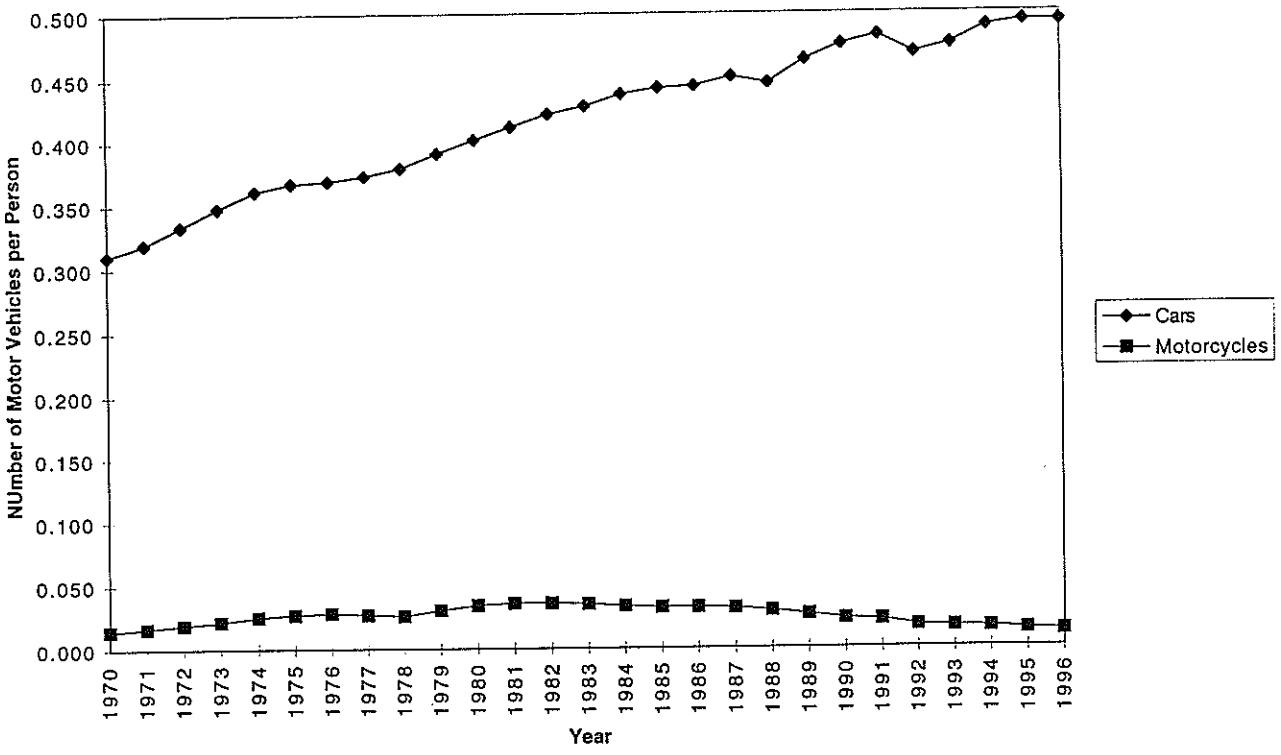


Table D.4 summarises the increases in car ownership over the consecutive 5 year periods since 1970. It is apparent that:

- The **absolute** change in cars/person over each 5 year period has decreased over the last 25 years, being at its highest in the period to 1975, average 57 cars/1000 persons, and dropping to 18 cars/1000 persons for the period to 1995. However, it was very similar in the other three periods , ending 1980, 1985 and 1990, at around an average 34-40 cars/1000 persons.

- The proportion rate of increase in cars/person has fallen, from 3.4% pa average in the period to 1975 to 1.5%-1.9% in the 3 periods up to 1990, and then down to 0.7% in the 1990-95 period. However, in the seven year period from 1988 - 1995 the increase in cars/person was 1.5% pa average.

- The absolute change was significantly lower in the period ending 1995. The data appears to show that car ownership may be approaching saturation level.

TABLE D.4 SUMMARY OF CAR OWNERSHIP CHANGES BY 5 YEAR PERIOD

5 Years Ending End	Cars/Person	5 Year Increase in Cars/Person		
		Absolute	Total %	Ave % pa
1970[1]	0.310			
1975	0.367	0.057	18.3%	3.4%
1980	0.402	0.034	9.4%	1.8%
1985	0.442	0.040	10.0%	1.9%
1990	0.476	0.034	7.6%	1.5%
1995	0.493	0.018	3.7%	0.7%

Note: (1) 1970 only

4. Factors Influencing Motor Vehicle Ownership

This section presents time series information on the following factors which might be expected to have influenced the trends in car ownership:

- GDP per person
- Car prices.

Table D.5 shows available data for years since 1951 on:

- Total NZ population (Statistics NZ)
- Real GDP (Statistics NZ)
- Real GDP per person - refer Figure D.4
- Car price index (Statistics NZ)
- Real car price index - refer Figure D.5.

Real GDP per person increased by 51% in the 20 year period from 1955 - 1975, an average annual increase of 2.1%; but only increased by 19.7% from 1975 to 1995, an average annual increase of 0.9%.

The car price index was prepared especially for the project by the Department of Statistics. Its features are:

- March quarter data
- based on weighted average of new and used car prices according to proportionate contributions to household expenditure in the Household Expenditure and Income Survey
- new car prices are collected from 15 urban area franchise dealers, relating to dominant types of cars sold
- used car prices are collected from survey of 300 used car dealers, covering the full range of vehicles sold but limited to vehicles less than 6 years old.

Real car prices (relative to the CPI) increased by 7.3% in the nine years 1966-1975, and fell by 16.6% in the 20 year period 1975-1995, an average annual decrease of 0.9%.

Figure D.6 plots year-on-year changes in cars/person against GDP per person and real car prices. Figure D.7 plots similar data on a 3-year averaged basis. It appears that:

- There is a reasonable correlation between growth rates in cars/person and in GDP/person, on a 3-year average basis. The cars/person growth rates are less volatile than the GDP/person growth rates. There is no clear evidence that the car/person trend either leads or lags behind the GDP/person trend.

Figure D4 Trends in GDP per person in New Zealand, for period 1955-1996.

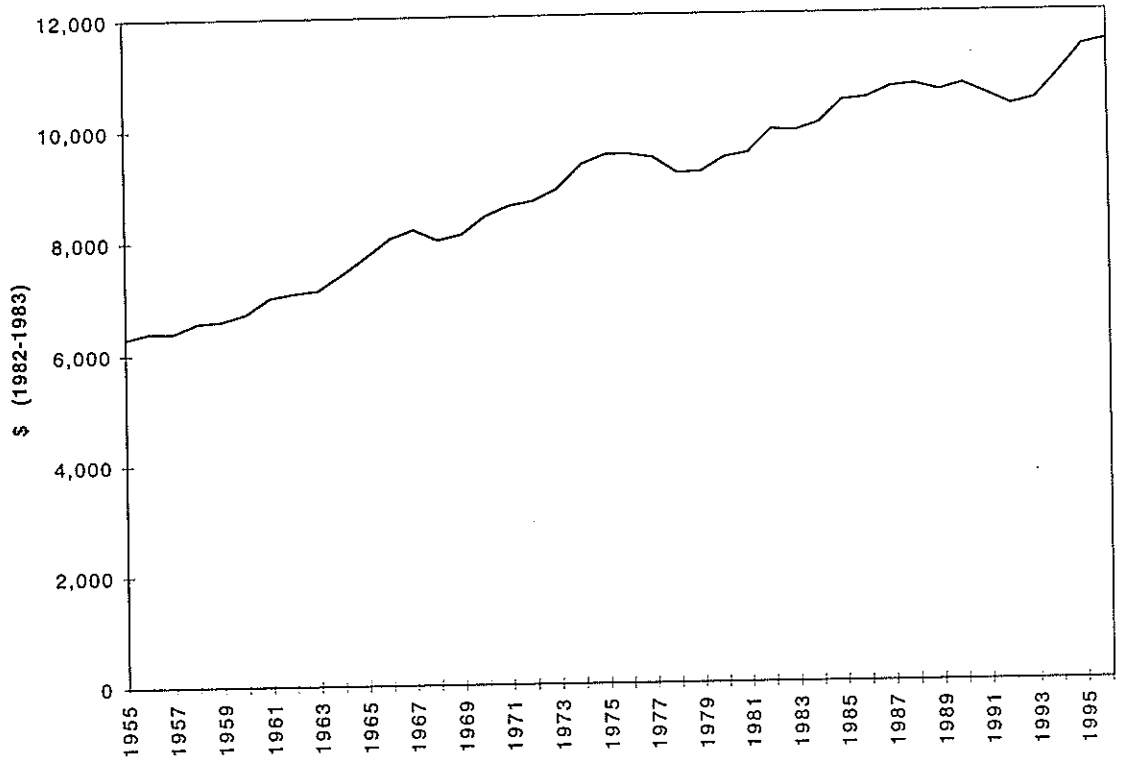


Figure D5 Trends in average real car prices in New Zealand for period 1966-1996.

- The substantial reduction in car prices since 1988 appears to be a major factor which influenced the strong growth in car ownership over the 1988-1991 period, when GDP growth was very weak (or negative).

Regression analysis has been undertaken in regard to the relationship between changes in Car Ownership rates and changes in Real GDP/person and Real Car Prices. There is a reasonable correlation between these variables when the 3 year moving average data is used. When the time is included as a variable there is a very good fit. This is shown in Figure D.8.

From this analysis it can be seen that changes in GDP and Car Prices do not fully explain the change in car ownership: there exists a strong time trend which is most likely related to societal factors encouraging car ownership rather than economic factors. The time trend over the last 23 years is a decrease in the rate of change in car ownership of 0.1% per year.

TABLE D.5: FACTORS INFLUENCING VEHICLE OWNERSHIP

Year	Population Mean (000)	Real GDP March Yr (M$ 82-83)	Real GDP Per Person	Car Price Index (Base=Dec 83)	CPI Index	Real Car Price Index
1951					48	
1952					54	
1953					57	
1954					60	
1955	2,105.8	13,252	6,293		62	
1956	2,150.3	13,744	6,392		64	
1957	2,194.1	14,009	6,385		66	
1958	2,246.1	14,737	6,561		67	
1959	2,298.8	15,148	6,590		71	
1960	2,345.6	15,744	6,712		73	
1961	2,388.0	16,711	6,998		73	
1962	2,441.4	17,270	7,074		75	
1963	2,498.3	17,799	7,124		77	
1964	2,550.1	18,884	7,405		78	
1965	2,601.2	20,038	7,703		82	
1966	2,647.2	21,259	8,031	94	84	1,118
1967	2,694.7	22,065	8,188	97	87	1,115
1968	2,735.2	21,875	7,998	107	92	1,168
1969	2,760.1	22,341	8,094	116	96	1,211
1970	2,788.9	23,469	8,415	120	101	1,185
1971	2,831.2	24,338	8,596	124	109	1,138
1972	2,876.0	24,957	8,678	133	119	1,114
1973	2,931.3	26,063	8,891	142	127	1,115
1974	2,993.6	27,933	9,331	148	139	1,061
1975	3,057.8	29,059	9,503	186	155	1,200
1976	3,111.3	29,548	9,497	229	179	1,279
1977	3,136.2	29,591	9,435	263	208	1,264
1978	3,143.5	28,775	9,154	298	238	1,252
1979	3,143.1	28,835	9,174	345	265	1,302
1980	3,138.0	29,571	9,424	385	306	1,258
1981	3,146.7	29,888	9,498	448	356	1,258
1982	3,161.2	31,357	9,919	520	411	1,265
1983	3,189.5	31,561	9,895	570	474	1,203
1984	3,230.6	32,422	10,036	641	499	1,285
1985	3,259.3	34,022	10,438	758	542	1,399
1986	3,273.3	34,284	10,474	832	625	1,331
1987	3,281.6	35,005	10,667	1011	716	1,412
1988	3,310.2	35,437	10,705	1061	811	1,308
1989	3,318.3	35,140	10,590	1010	853	1,184
1990	3,336.5	35,728	10,708	977	908	1,076
1991	3,373.1	35,482	10,519	914	958	954
1992	3,415.8	35,243	10,318	945	974	970
1993	3,452.0	36,003	10,430	924	984	939
1994	3,491.1	37,985	10,881	994	998	996
1995	3,539.3	40,274	11,379	1,023	1,022	1,001
1996	3,618.3	41,482	11,464	1,037	1,056	982

Notes: Figures for the year ended 31 March, unless stated otherwise

Figure D6 Annual changes in cars per person, GDP per person, and car prices, in New Zealand for period 1971-1996.

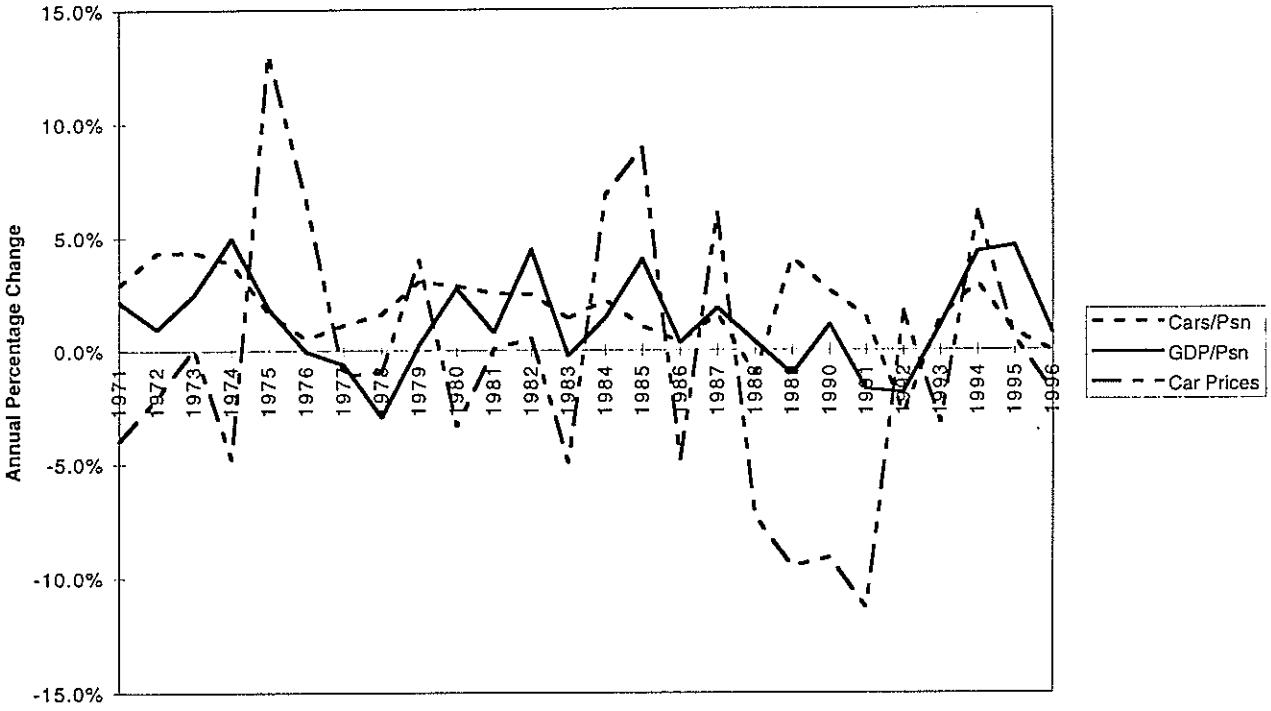


Figure D7 Three-year change in cars per person, GDP per person, and car prices in New Zealand for period 1973-1996.

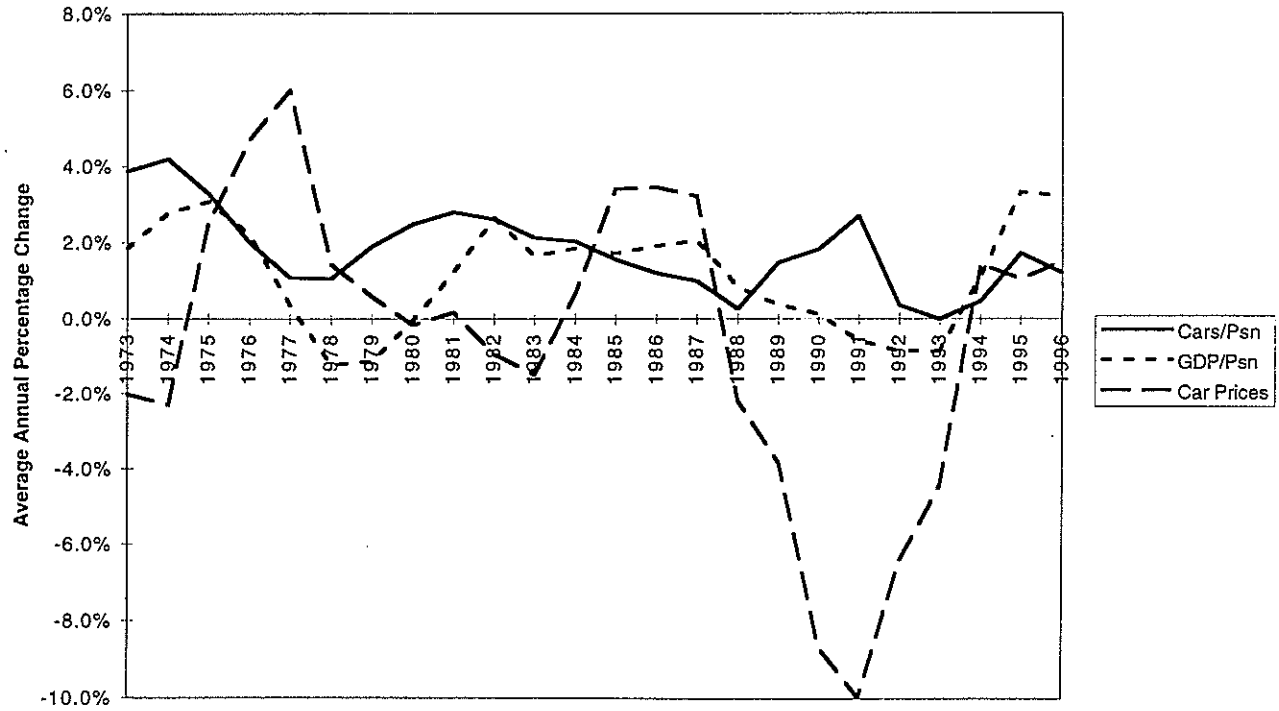
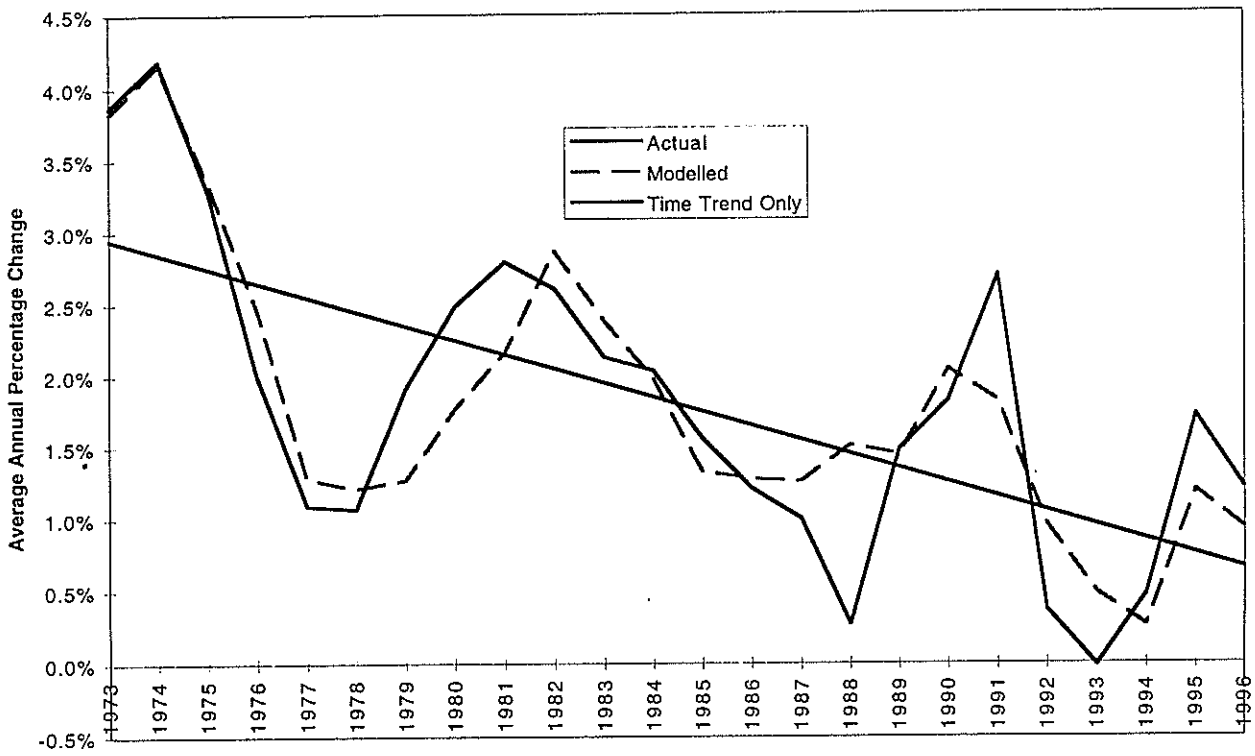


Figure D8 Regression of 3-year moving average of changes in real GDP per person and real car price against cars per person in New Zealand for the period 1973-1996.



Appendix E

New Zealand Census Statistics for Motor Vehicles

Appendix E
New Zealand Census Statistics for Motor Vehicles

1. Introduction

This Appendix examines the motor vehicle ownership statistics produced from the NZ Statistics Census data.

It is structured as follows:

- Section E.1 provides statistics on motor vehicle ownership at a regional level, from the 1986, 1991 and 1996 Census.
- Section E.2 presents national household motor vehicle ownership statistics by family income group from the 1991 Census.

2. Census Statistics of Motor Vehicle Ownership

2.1 Analysis of Census Data

Tabulations have been obtained from the 1986, 1991 and 1996 Censii of the proportions of households in each region owning different numbers of vehicles, the average vehicles/household and vehicles/person in each region. This data is shown in Tables E.1-E.3. The motor vehicle ownership rate from each Census by region is graphed in Figure E.1.

In this context, the number of motor vehicles recorded is those available for private use in the care of persons in the dwelling on census night. It includes cars, station wagons, vans, trucks and other vehicles used on public roads, and also any business vehicles available for private use; but it excludes motorcycles/scooters and tractors, and any business vehicles not kept at private dwellings (no breakdowns by vehicle type are available).

Notable features of these statistics include:

- Nationally, the average vehicles/household has increased from 1.36 in 1986 to 1.48 in 1996; and the average vehicles per person from 0.45 in 1986 to 0.52 in 1996.
- Nationally, the proportion of households with no vehicles has decreased from 13% in 1986 to 12% in 1996. The proportion with more than 1 vehicle has increased from 38% in 1986 to 45% in 1996.
- Auckland had the highest level of vehicles per household in 1996 at 1.56; however, Nelson/Marlborough had the highest level of vehicles per person in 1996 at 0.60, closely followed by Canterbury at 0.59 and Southland at 0.57. Auckland's ratio of vehicles per person in 1996 was 0.53. Gisborne had the lowest level of vehicles per household in 1996 at 1.33, and vehicles per person at 0.46.

TABLE E.1: HOUSEHOLD VEHICLE OWNERSHIP BY REGION (1986 Census)

Region	Percentage of Households with N Motor Vehicles						Avg Vehicles Per Hhold	Avg House-hold Size	Avg Vehicles Per Person
	0	1	2	3	4	5			
Northland	4,335	20,160	10,833	2,319	516	192	1.35	3.04	0.45
	11%	53%	28%	6%	1%	1%			
Auckland	40,488	129,078	84,375	20,520	5,370	1,767	1.39	2.93	0.47
	14%	46%	30%	7%	2%	1%			
Waikato	10,707	52,689	29,187	6,459	1,554	507	1.38	3.01	0.46
	11%	52%	29%	6%	2%	1%			
Bay of Plenty	6,321	31,770	17,466	3,663	834	267	1.37	2.98	0.46
	10%	53%	29%	6%	1%	0%			
Gisborne	1,863	7,482	3,636	723	147	51	1.28	3.09	0.41
	13%	54%	26%	5%	1%	0%			
Hawke's Bay	5,493	22,587	12,951	2,979	645	231	1.37	2.93	0.47
	12%	50%	29%	7%	1%	1%			
Taranaki	4,305	18,420	9,642	2,112	510	180	1.34	2.92	0.46
	12%	52%	27%	6%	1%	1%			
Manawatu/Wanganui	9,507	36,783	19,440	4,431	1,032	360	1.33	2.88	0.46
	13%	51%	27%	6%	1%	1%			
Wellington	22,626	65,445	33,102	6,465	1,602	549	1.24	2.84	0.44
	17%	50%	26%	5%	1%	0%			
Nelson/Marlborough	3,525	17,922	10,158	2,349	555	252	1.41	2.79	0.50
	10%	52%	29%	7%	2%	1%			
West Coast	1,575	6,183	2,685	567	132	51	1.26	2.81	0.45
	14%	55%	24%	5%	1%	0%			
Canterbury	18,585	70,395	43,137	10,770	2,883	1,122	1.41	2.73	0.52
	13%	48%	29%	7%	2%	1%			
Otago	9,336	29,994	15,708	3,714	930	390	1.31	2.76	0.47
	16%	50%	26%	6%	2%	1%			
Southland	3,885	16,032	10,053	2,430	621	261	1.42	2.95	0.48
	12%	48%	30%	7%	2%	1%			
Not Applicable	42	111	42	18	0	0	1.17	2.95	0.40
	20%	52%	20%	8%	0%	0%			
Total	142,551	524,940	302,373	69,501	17,331	6,180	1.36	2.89	0.45
	13%	49%	28%	7%	2%	1%			

TABLE E.2: HOUSEHOLD VEHICLE OWNERSHIP BY REGION (1991 Census)

Region	Percentage of Households with N Motor Vehicles						Avg Vehicles Per Hhold	Avg House-hold Size	Avg Vehicles Per Person
	0	1	2	3	4	5			
Northland	4,956	21,480	12,075	2,439	570	180	1.35	2.85	0.47
	12%	52%	29%	6%	1%	0%			
Auckland	39,510	133,620	101,685	26,049	7,038	2,469	1.47	2.87	0.51
	13%	43%	33%	8%	2%	1%			
Waikato	11,097	52,863	34,353	7,884	1,905	687	1.44	2.86	0.50
	10%	49%	32%	7%	2%	1%			
Bay of Plenty	7,482	34,059	21,270	4,449	918	330	1.39	2.79	0.50
	11%	50%	31%	6%	1%	0%			
Gisborne	2,064	7,419	3,591	753	153	45	1.26	2.91	0.43
	15%	53%	26%	5%	1%	0%			
Hawke's Bay	5,670	22,749	14,433	3,357	756	270	1.40	2.77	0.51
	12%	48%	31%	7%	2%	1%			
Taranaki	4,227	18,588	10,755	2,316	537	156	1.37	2.77	0.49
	12%	51%	29%	6%	1%	0%			
Manawatu/Wanganui	9,462	37,074	22,536	5,151	1,251	483	1.39	2.76	0.50
	12%	49%	30%	7%	2%	1%			
Wellington	20,862	65,340	39,903	8,559	1,962	780	1.33	2.75	0.48
	15%	48%	29%	6%	1%	1%			
Nelson/Marlborough	3,561	18,465	12,219	2,835	696	321	1.47	2.65	0.55
	9%	48%	32%	7%	2%	1%			
West Coast	1,467	6,030	3,084	615	156	69	1.32	2.64	0.50
	13%	53%	27%	5%	1%	1%			
Canterbury	17,934	69,585	50,238	13,065	3,645	1,521	1.49	2.63	0.57
	11%	45%	32%	8%	2%	1%			
Otago	8,889	29,151	18,552	4,302	1,098	483	1.38	2.64	0.52
	14%	47%	30%	7%	2%	1%			
Southland	3,915	16,119	10,572	2,538	654	270	1.44	2.78	0.52
	11%	47%	31%	7%	2%	1%			
Total	141,096	532,542	355,266	84,312	21,339	8,064	1.42	2.78	0.49
	12%	47%	31%	7%	2%	1%			

TABLE E.3: HOUSEHOLD VEHICLE OWNERSHIP BY REGION (1996 Census)

Region	Percentage of Households with N Motor Vehicles				Avg Vehicles Per Hhold	Avg House-hold Size	Avg Vehicles Per Person
	0	1	2	3+			
Northland	5,727	21,189	14,241	4,053	1.38	2.74	0.50
	13%	47%	31%	9%			
Auckland	38,094	130,812	119,859	47,484	1.56	2.93	0.53
	11%	39%	36%	14%			
Waikato	12,720	51,429	39,408	13,284	1.48	2.78	0.53
	11%	44%	34%	11%			
Bay of Plenty	8,400	34,290	25,911	7,989	1.43	2.72	0.53
	11%	45%	34%	10%			
Gisborne	2,073	6,861	4,113	1,266	1.33	2.90	0.46
	14%	48%	29%	9%			
Hawke's Bay	5,955	21,423	16,281	5,385	1.47	2.69	0.55
	12%	44%	33%	11%			
Taranaki	4,464	17,406	11,973	3,324	1.39	2.65	0.53
	12%	47%	32%	9%			
Manawatu/Wanganui	9,924	35,691	24,288	8,052	1.42	2.69	0.53
	13%	46%	31%	10%			
Wellington	21,645	66,045	43,077	12,369	1.36	2.69	0.51
	15%	46%	30%	9%			
Nelson/Marlborough	4,050	18,399	14,544	4,905	1.53	2.56	0.60
	10%	44%	35%	12%			
West Coast	1,536	5,700	3,411	954	1.35	2.52	0.54
	13%	49%	29%	8%			
Canterbury	18,945	69,531	58,428	22,677	1.53	2.58	0.59
	11%	41%	34%	13%			
Otago	9,168	28,914	20,967	7,182	1.44	2.57	0.56
	14%	44%	32%	11%			
Southland	3,999	14,532	11,646	4,236	1.50	2.64	0.57
	12%	42%	34%	12%			
Total	146,700	522,222	408,147	143,160	1.48	2.74	0.52
	12%	43%	33%	12%			

Figure E.1 Vehicle Ownership by Region: Vehicles per Person

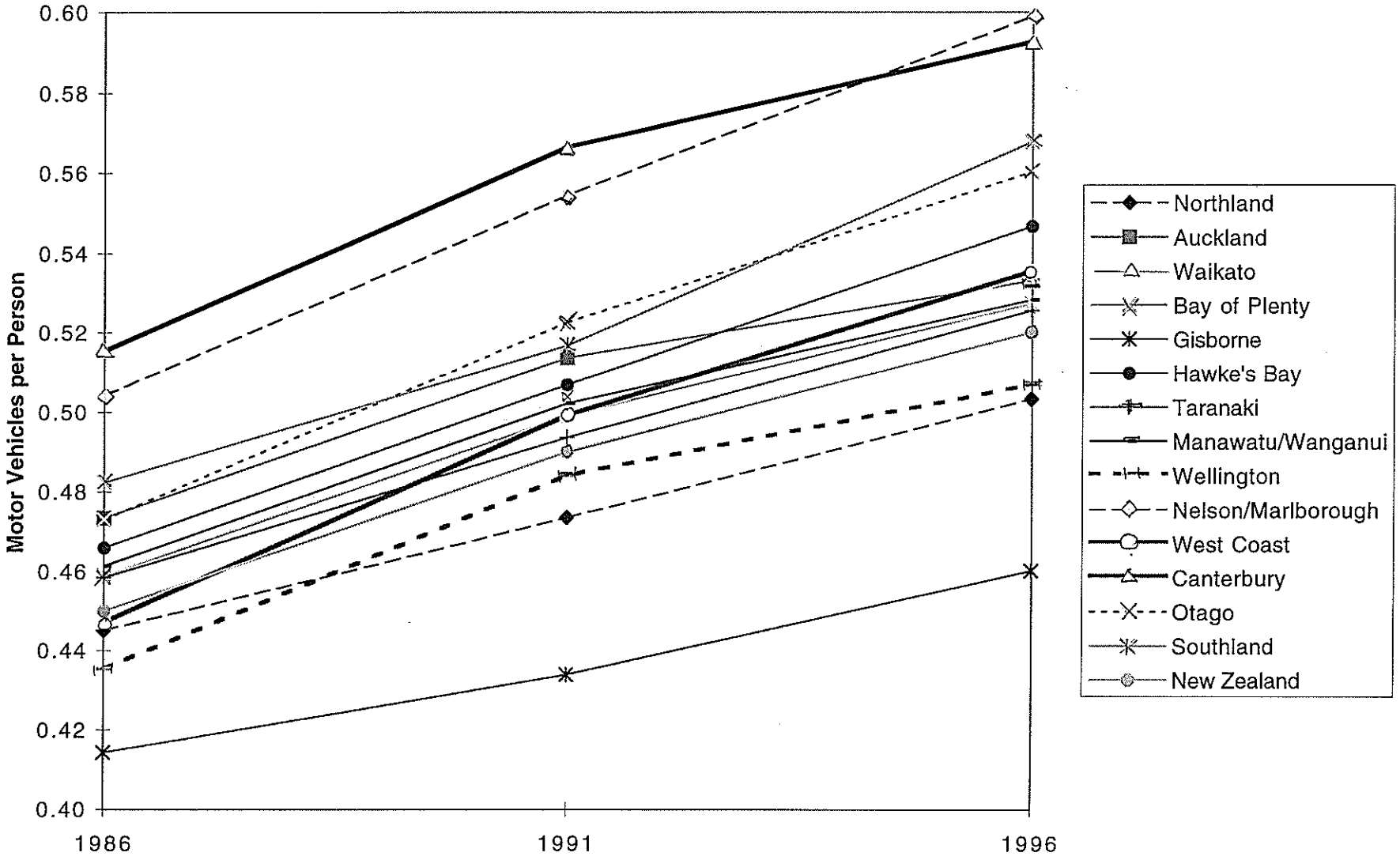
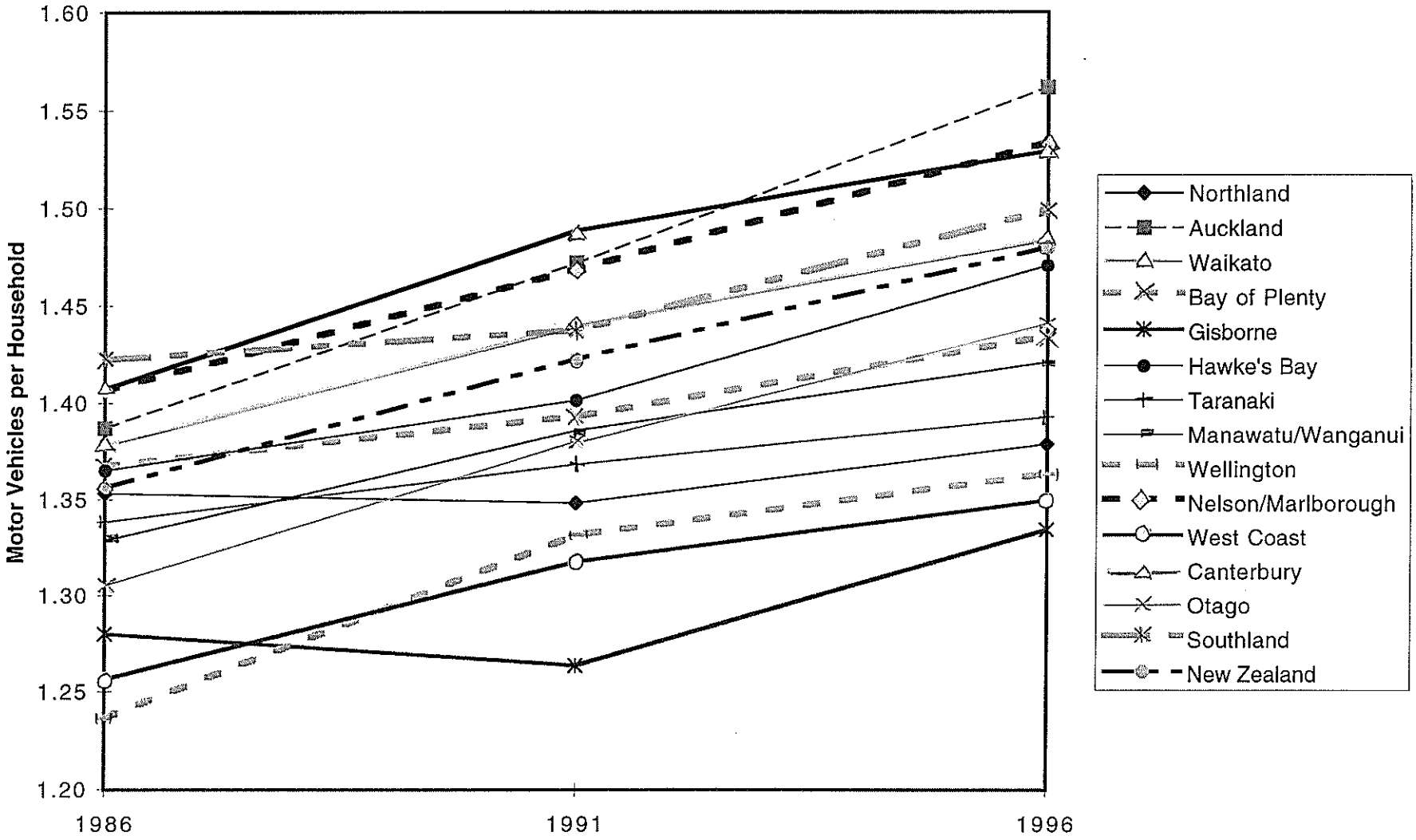


Figure E.2 Vehicle Ownership by Region: Vehicles per Household



2.2 Reconciliation with MRC Figures

The census data provides the best basis for forecasting motor vehicle ownership levels at the regional level, or at more detailed levels (zonal or TLA): household number projections are available at the regional and more detailed levels, and the census motor vehicle ownership data is household based. However, the census data does not represent all motor vehicles: not only are motorcycles deliberately excluded, but company owned vehicles which are not kept at private residences overnight are excluded.

The MRC statistics are the official records for motor vehicle ownership, and the BAH vehicle ownership time series is based on the MRC September quarterly returns. To enable estimates of motor vehicle ownership to be made at the regional level from census data, it is necessary to reconcile the census data with the MRC statistics. The adjustments made by BAH to produce a motor vehicle ownership time series can then be applied to the census data.

The Census (motor vehicle) and corresponding MRC (March) statistics are compared in Table E.4.

TABLE E.4 COMPARISON OF CENSUS & MRC MOTOR VEHICLE STATISTICS

Census - Motor Vehicles	MCR - 'Cars'
Definition Those motor vehicles available for private use in the care of persons in the dwelling on census night; excluding certain categories.	All licensed motor vehicles included in the 'car' category for licensing purposes.
Vehicle Types Included • Cars • Vans	• Cars (licensed) • Rental cars • Taxis • Trade Plates
Vehicle Types Possibly Included • Taxis • Rental cars • Trucks (some)	
Vehicle Types Excluded • Vehicles solely for business • Motorcycles • Tractors • Most farm vehicles • Exempt vehicles • Trailers/Caravans	• Motorcycles • Tractors • Other farm vehicles • Exempt vehicles • Trailers/ Caravans • Trucks
Notes • Includes unlicensed/late licensed vehicles in relevant categories	• Pre-87: 'cars' category included rental cars, taxis & trade plates. These have therefore also been included in post-87 statistics. • Pre-87: includes cars scrapped during previous 9 months • Post-87: excludes late licensed vehicles.

The 1986, 1991 and 1996 Census figures for 'motor vehicles' are compared in Table E.4 below with the MRC March figures for cars (includes cars, rental cars and trade plates).

TABLE E.5 CENSUS / MRC VEHICLES: 1986, 1991 & 1996					
Census	Census Motor Vehicles	MRC March-Cars	Adjusted MRC Cars[1]	Difference: MRC-Census (no)	Diff MRC-Census (%)
1986	1,476,002	1,531,425	1,485,482	+ 55,423	+ 3.6
1991	1,659,383	1,556,836	1,634,678	- 102,547	- 6.6
1996	1,885,202	1,662,448	1,745,570	-222,754	-13.4

Note: (1) adjustments made by BAH to NZ Statistics data.

The reasons for the differences between the Census and MRC data are discussed below:

- 1986:
  The 1986 MRC figure is 3.6% higher than the Census figure. The most likely reasons for this are:
- MRC includes cars used solely for business purposes, whereas the Census excludes these: however, these are likely to constitute very small numbers
- MRC includes scrapped vehicles: Census likely to exclude these. This could be a significant difference, in the order of 3-4% in favour of MRC.

- 1991 & 1996
  The 1991 Census figure is 6.6% higher than the MRC figure, and the 1996 Census figure is 13.4% higher. The most likely reasons for this are:
- Census includes vans and trucks kept at home and used for private purposes, whereas MRC doesn't.
- Census includes late relicensees, whereas MRC excludes these. Our estimates are that late relicensees are around 5% of licensed vehicles.

The difference between the Census figures and the MRC figures can be reasonably well accounted for in 1986 and 1991: the 1986 MRC figure includes scrapped vehicles which are estimated to be around 3-4% of the MRC total; and, the post 1986 MRC figures exclude late relicensed vehicles which are estimated to be around 5% of the MRC total. Applying these adjustments results in the Census and MRC figures being very close together in 1986 and 1991.

However, the 1996 Census figure is over 8% higher than the MRC figure after late relicensed vehicles are included.

The difference between the Census and MRC figures in 1996 is also seen when the change in vehicles per person is analysed. For the period 1985 to 1990 the increase in MRC 'cars per person' was close to that of Census 'vehicles per person' - 7.6% and 8.5% respectively. However, for the period 1990 to 1995 MRC 'cars per person' increased by 3.7% compared to 5.9% for Census 'vehicles per person'.

The reason for this difference between the Census and MRC figures in 1996 is not readily apparent.

In summary:

- the 1986 Census figure appears to be around 3-4% lower than the MRC figure. However, pre-1987 MRC figures are considered to be an over-statement of 'active vehicles' by 3-4%. The 1986 Census figure could therefore be taken as a good representation of the level of 'active vehicles'.

- the 1991 Census figure is around 6% higher than the March MRC figure. However, post 1987 MRC figures are considered to be around 5% below the level of 'active vehicles'. The 1991 Census figure could therefore be taken as a reasonably good representation of the level of 'active vehicles', although slightly on the high side.

- the 1996 Census figure is around 13% higher than the March MRC figure. Thus, after taking account of the 5% under-statement assumed for post-1987 MRC figures, the 1996 Census figure is still around 8% higher than the MRC figure. No readily apparent reason has been determined for this difference. Given that the MRC figures are likley to be more reliable than the Census figures (being based on actual transactions rather than survey responses), the 1996 Census figures cannot be taken as an accurate representation of 'active vehicles'. Further analysis will be required to determine the scaling factors which should be applied: different factors may be applicable to different regions.

3. 1991 Census: Motor Vehicle Ownership by Household Type

Tabulations from the 1991 Census have been obtained on the average number of motor vehicles per household, the average number of persons per household and the percentage of households having 0, 1, 2, and 3+ motor vehicles available, with breakdowns by:

- household type
- family income group.

This information is presented in tables E.5 and E.6, and figures E.3 to E.16.

Notable features of these statistics include:

- Overall the average vehicles/household increases by a factor of about 3 from the lowest income group (0.66 vehicles/household) to the highest income group (2.13 vehicles/household). However, part of this increase may be ascribed to household size effects. The average vehicles/person increases by a factor of only 1.5 for the lowest income group (0.42 vehicles/household) to the highest income group (0.63 vehicles/household).

- Households that contain a greater number of adults tend to have more vehicles per household.
  - most two parent families have 2 to 3 vehicles (average 1.56 to 2.31 vehicles per household),
  - most multiple families have 1 vehicle (average 1.68 vehicles per household)
  - most couples have 1 to 2 vehicles (average 1.23 to 1.59 vehicles per household),
  - most one parent families have 1 vehicle (average 0.75 to 1.29 vehicles per household),
  - most single people have 1 vehicle (average 0.69 to 0.78 vehicles per household).

- Households that contain retired people tend to have a fewer vehicles per household. For example:
  - couples with at least one person retired average 1.23 vehicles per household compared to an average of 1.59 for couples with neither person retired,
  - retired single people average 0.69 vehicles per household compared to non-retired single people 0.72.

TABLE E.6: NATIONAL HOUSEHOLD MOTOR VEHICLE OWNERSHIP STATISTICS - 1991 CENSUS

Family Income	Percentage of Households with ... 0 Vehicles	1 Vehicle	2 Vehicles	3+ Vehicles	N/S Vehicles	No. of Hholds	Vehicles/ Hhold	Persons/ Hhold	Vehicles/ Person
Type 1: One Parent Families With Dependent Children Only									
-> $10K	41.4	50.2	4.1	0.9	3.5	9,972	0.60	2.70	0.22
$10-15K	34.9	58.9	3.4	0.5	2.3	26,490	0.69	2.73	0.25
$15-20K	23.5	68.8	5.2	0.6	1.9	10,920	0.81	3.06	0.26
$20-25K	13.7	74.0	9.3	1.0	2.0	3,567	0.96	2.76	0.35
$25-30K	8.9	77.3	11.1	1.6	1.2	2,649	1.05	2.64	0.40
$30-40K	4.3	80.3	12.4	2.0	1.1	2,754	1.11	2.61	0.43
$40-50K	3.6	77.3	14.9	2.8	1.4	1,089	1.17	2.55	0.46
$50-70K	3.1	73.0	19.9	2.5	1.6	489	1.23	2.58	0.48
$70K ->	1.9	64.8	25.5	6.6	1.3	318	1.38	2.64	0.52
N/S	33.3	48.2	6.0	1.3	11.2	5,328	0.63	2.97	0.21
Total	29.3	61.3	5.5	0.9	3.0	63,576	0.75	2.79	0.27
Type 2: One Parent Families With Adult Children With Or Without Dependent Children									
-> $10K	29.2	49.0	16.0	3.3	2.4	960	0.90	2.49	0.36
$10-15K	31.3	49.1	15.0	2.1	2.5	2,949	0.87	2.43	0.36
$15-20K	28.0	50.6	17.2	2.6	1.7	4,203	0.93	2.52	0.37
$20-25K	20.5	51.0	22.6	4.0	2.0	5,337	1.08	2.52	0.43
$25-30K	15.6	47.6	29.6	5.4	1.7	4,665	1.23	2.46	0.50
$30-40K	9.5	46.6	35.5	7.1	1.4	7,707	1.41	2.43	0.58
$40-50K	6.1	41.7	39.4	11.7	1.1	4,539	1.59	2.52	0.63
$50-70K	3.8	32.5	43.5	19.4	0.8	4,155	1.83	2.61	0.70
$70K ->	2.5	23.2	41.8	31.5	0.9	1,968	2.13	2.79	0.76
N/S	19.6	48.3	21.1	6.1	4.9	8,373	1.11	2.97	0.37
Total	15.8	45.3	28.6	8.2	2.1	44,859	1.29	2.58	0.50
Type 3: Two Parent Families With Dependent Children Only									
-> $10K	9.4	56.2	28.6	4.1	1.8	3,288	1.29	4.08	0.32
$10-15K	13.2	56.8	24.8	3.8	1.5	7,773	1.20	3.99	0.30
$15-20K	8.8	58.2	27.7	4.1	1.2	12,558	1.26	4.11	0.31
$20-25K	5.3	57.2	32.0	4.4	1.0	19,608	1.35	4.17	0.32
$25-30K	3.0	52.8	38.2	5.2	0.8	19,689	1.47	4.14	0.36
$30-40K	2.1	49.0	42.4	5.6	0.8	45,168	1.53	4.14	0.37
$40-50K	1.0	41.8	49.8	6.6	0.7	34,749	1.62	4.11	0.39
$50-70K	0.5	33.3	57.4	8.2	0.7	42,270	1.74	4.05	0.43
$70K ->	0.2	20.2	68.1	10.8	0.7	32,697	1.89	4.08	0.46
N/S	4.1	48.7	40.2	5.4	1.6	46,320	1.47	4.20	0.35
Total	2.9	43.6	46.1	6.5	1.0	264,114	1.56	4.11	0.38
Type 4: Two Parent Families With Adult and Dependent Children									
-> $10K	13.1	41.6	29.9	13.9	1.5	138	1.47	4.71	0.31
$10-15K	14.0	41.1	30.5	13.6	0.8	237	1.47	5.10	0.29
$15-20K	9.1	48.1	26.4	15.1	1.3	594	1.50	4.77	0.31
$20-25K	9.2	46.1	29.8	13.1	1.8	1,074	1.50	4.89	0.31
$25-30K	5.2	41.1	35.8	17.4	0.5	1,383	1.71	4.80	0.36
$30-40K	3.5	33.1	38.9	23.3	1.3	3,693	1.89	4.80	0.39
$40-50K	2.3	27.9	39.1	30.2	0.5	4,785	2.07	4.77	0.43
$50-70K	0.8	18.9	41.8	37.9	0.7	9,240	2.31	4.68	0.49
$70K ->	0.4	10.7	38.5	49.8	0.7	12,483	2.58	4.80	0.54
N/S	3.8	32.2	39.3	23.0	1.7	13,662	1.86	5.04	0.37
Total	2.4	24.4	39.0	33.1	1.1	47,283	2.13	4.86	0.44

Family Income	Percentage of Households with ... 0 Vehicles	1 Vehicle	2 Vehicles	3+ Vehicles	N/S Vehicles	No. of Hholds	Vehicles/ Hhold	Persons/ Hhold	Vehicles/ Person
Type 5: Two Parent Families With Adult Children Only									
-> $10K	4.6	36.4	35.9	22.3	0.9	219	1.80	3.12	0.58
$10-15K	5.9	38.5	33.5	18.7	3.5	342	1.68	3.09	0.54
$15-20K	7.4	41.4	34.6	14.8	1.8	1,197	1.56	3.06	0.51
$20-25K	5.7	38.3	37.0	17.7	1.4	2,484	1.68	3.09	0.54
$25-30K	4.5	35.6	39.2	19.4	1.3	3,564	1.74	3.09	0.56
$30-40K	3.1	27.5	42.3	26.1	0.9	7,677	1.98	3.15	0.63
$40-50K	1.8	21.6	41.5	34.1	1.0	8,592	2.16	3.21	0.67
$50-70K	0.9	15.6	40.2	42.7	0.7	17,052	2.37	3.30	0.72
$70K ->	0.3	8.2	30.9	59.8	0.7	23,070	2.76	3.57	0.77
N/S	2.6	26.0	39.6	30.4	1.4	12,804	2.07	3.42	0.61
Total	1.8	19.2	37.4	40.7	1.0	77,007	2.31	3.33	0.69
Type 6: Couples Only With One Or Both Retired									
-> $10K	10.7	62.4	23.0	1.5	2.4	1,050	1.14	1.98	0.58
$10-15K	9.8	67.6	19.2	1.3	2.1	9,252	1.08	2.01	0.54
$15-20K	8.2	72.1	17.3	1.1	1.4	38,715	1.11	1.98	0.56
$20-25K	4.9	66.0	26.2	1.7	1.3	22,191	1.26	2.01	0.63
$25-30K	3.2	61.4	32.2	2.0	1.2	8,742	1.32	2.01	0.66
$30-40K	3.2	57.6	35.4	2.5	1.3	14,223	1.38	1.98	0.70
$40-50K	1.8	49.6	44.0	3.3	1.3	5,610	1.47	1.98	0.74
$50-70K	1.2	40.4	52.5	4.7	1.2	4,998	1.62	2.01	0.81
$70K ->	0.8	28.9	62.6	6.5	1.1	3,102	1.74	1.98	0.88
N/S	11.5	58.0	25.1	2.2	3.2	3,468	1.14	1.98	0.58
Total	5.9	63.5	27.2	1.9	1.4	111,351	1.23	1.98	0.62
Type 7: Couples Only With Neither Retired									
-> $10K	8.1	52.6	32.5	5.1	1.7	3,120	1.35	1.98	0.68
$10-15K	11.0	57.7	26.6	3.2	1.5	6,810	1.23	1.98	0.62
$15-20K	7.4	54.7	32.7	4.0	1.2	7,206	1.32	2.01	0.66
$20-25K	5.0	50.2	38.8	4.8	1.3	10,734	1.41	1.98	0.71
$25-30K	3.4	48.2	41.9	5.4	1.1	10,878	1.47	1.98	0.74
$30-40K	2.4	46.1	44.1	6.2	1.1	25,755	1.56	2.01	0.78
$40-50K	1.4	42.4	48.6	6.7	0.9	23,652	1.59	2.01	0.79
$50-70K	0.9	37.0	53.5	7.7	0.8	35,187	1.68	2.01	0.84
$70K ->	0.5	26.3	63.2	9.4	0.7	23,691	1.83	2.01	0.91
N/S	8.2	47.3	35.3	6.4	2.9	3,609	1.38	2.01	0.69
Total	2.7	41.8	47.7	6.7	1.1	150,642	1.59	2.01	0.79
Type 8: Couples Only With Retired N/S									
-> $10K	8.3	46.5	38.2	5.6	1.4	144	1.41	2.01	0.70
$10-15K	4.9	54.7	34.4	4.5	1.5	267	1.38	2.01	0.69
$15-20K	5.5	56.3	34.9	1.7	1.7	423	1.32	2.01	0.66
$20-25K	5.6	51.3	37.3	3.5	2.4	630	1.38	2.01	0.69
$25-30K	3.6	48.0	39.8	6.2	2.5	642	1.50	2.01	0.75
$30-40K	2.6	45.9	43.3	6.7	1.7	1,338	1.53	2.01	0.76
$40-50K	1.9	40.8	48.2	7.0	2.2	957	1.59	1.98	0.80
$50-70K	1.1	34.9	52.1	9.7	2.2	1,179	1.71	2.01	0.85
$70K ->	1.0	26.4	59.6	11.3	1.7	1,017	1.83	1.98	0.92
N/S	4.8	47.8	39.9	5.1	2.3	10,131	1.44	2.01	0.72
Total	4.0	45.5	42.4	6.0	2.2	16,725	1.50	2.01	0.75

Family Income	Percentage of Households with ... 0 Vehicles	1 Vehicle	2 Vehicles	3+ Vehicles	N/S Vehicles	No. of Hholds	Vehicles/ Hhold	Persons/ Hhold	Vehicles/ Person
Type 9: Single People Not Retired									
-> $10K	48.4	44.8	2.6	0.6	3.5	25,122	0.51	1.02	0.50
$10-15K	43.5	51.2	2.2	0.5	2.5	20,634	0.57	1.02	0.56
$15-20K	27.1	64.6	5.1	1.1	2.2	9,567	0.78	0.99	0.79
$20-25K	21.1	69.3	6.6	1.0	2.1	7,890	0.87	1.02	0.85
$25-30K	14.8	74.8	7.4	1.2	1.9	7,035	0.96	0.99	0.97
$30-40K	10.5	78.8	7.7	1.5	1.6	8,277	0.99	0.99	1.00
$40-50K	8.3	80.5	8.5	1.4	1.4	4,023	1.02	0.99	1.03
$50-70K	7.1	79.9	9.9	1.9	1.3	2,268	1.05	0.99	1.06
$70K ->	6.9	75.9	12.1	3.6	1.4	1,242	1.14	0.99	1.15
N/S	46.1	40.2	2.9	1.1	9.8	1,815	0.51	0.99	0.52
Total	32.7	59.2	4.6	0.9	2.6	87,873	0.72	1.02	0.71
Type 10: Single People Retired									
-> $10K	47.8	46.3	2.2	0.4	3.4	32,367	0.54	0.99	0.55
$10-15K	41.8	53.7	1.8	0.3	2.4	33,504	0.57	1.02	0.56
$15-20K	25.6	67.9	4.0	0.6	1.9	13,431	0.78	0.99	0.79
$20-25K	18.2	73.5	5.8	0.9	1.6	9,465	0.90	0.99	0.91
$25-30K	13.1	76.7	7.1	1.3	1.9	7,680	0.96	1.02	0.94
$30-40K	9.8	80.0	7.4	1.1	1.7	8,043	0.96	0.99	0.97
$40-50K	8.2	80.6	8.3	1.4	1.5	3,552	1.02	0.99	1.03
$50-70K	6.5	80.0	9.9	2.1	1.5	2,076	1.05	1.02	1.03
$70K ->	5.7	78.6	11.6	3.2	1.0	1,266	1.14	0.99	1.15
N/S	46.9	42.1	3.3	0.6	7.2	1,920	0.51	0.99	0.52
Total	33.4	59.8	3.8	0.7	2.5	113,307	0.69	1.02	0.68
Type 11: Single People Retired N/S									
-> $10K	44.8	47.6	2.7	1.0	4.0	6,603	0.54	0.99	0.55
$10-15K	40.5	53.4	2.5	0.8	2.9	4,782	0.60	1.02	0.59
$15-20K	25.0	65.9	5.1	1.5	2.6	2,259	0.81	1.02	0.79
$20-25K	19.9	71.1	5.5	1.8	1.7	1,938	0.90	0.99	0.91
$25-30K	15.2	73.0	7.1	2.2	2.5	1,614	0.96	0.99	0.97
$30-40K	12.3	75.7	8.0	2.0	2.0	1,704	0.99	1.02	0.97
$40-50K	9.0	77.2	9.8	1.5	2.6	744	1.02	1.02	1.00
$50-70K	8.9	78.4	9.2	2.3	1.2	405	1.05	1.02	1.03
$70K ->	9.0	68.2	16.7	4.1	2.0	246	1.17	1.02	1.15
N/S	19.4	51.0	13.7	2.6	13.3	14,511	0.87	0.99	0.88
Total	26.5	56.0	8.4	1.9	7.2	34,806	0.78	0.99	0.79
Type 12: Multiple Families									
-> $10K	16.6	39.7	27.2	14.5	1.9	4,632	1.44	4.26	0.34
$10-15K	17.0	39.5	27.1	14.5	1.8	7,164	1.44	4.35	0.33
$15-20K	12.9	38.8	30.2	16.3	1.8	7,164	1.53	4.47	0.34
$20-25K	10.4	36.8	31.4	19.6	1.7	6,435	1.65	4.62	0.36
$25-30K	9.5	33.5	34.1	21.5	1.3	4,983	1.74	4.56	0.38
$30-40K	7.8	31.7	34.0	25.1	1.4	8,667	1.83	4.50	0.41
$40-50K	6.1	28.4	33.8	30.7	1.0	6,474	2.01	4.53	0.44
$50-70K	6.0	27.4	34.6	30.5	1.5	6,966	2.04	4.32	0.47
$70K ->	4.6	25.6	36.1	32.3	1.3	4,977	2.07	4.20	0.49
N/S	12.0	35.8	28.3	18.2	5.7	28,746	1.53	5.13	0.30
Total	10.7	34.3	30.8	21.3	2.9	86,205	1.68	4.68	0.36

Family Income	Percentage of Households with ... 0 Vehicles	1 Vehicle	2 Vehicles	3+ Vehicles	N/S Vehicles	No. of Hholds	Vehicles/ Hhold	Persons/ Hhold	Vehicles/ Person
All Family Types									
-> $10K	41.6	46.8	6.5	1.7	3.2	87,615	0.66	1.56	0.42
$10-15K	32.5	54.9	8.5	1.8	2.2	120,204	0.78	1.97	0.40
$15-20K	15.0	64.1	16.5	2.8	1.6	108,237	1.06	2.32	0.46
$20-25K	9.8	59.7	24.6	4.4	1.5	91,353	1.24	2.56	0.48
$25-30K	7.1	56.3	29.4	5.9	1.3	73,524	1.34	2.68	0.50
$30-40K	4.3	51.1	35.7	7.8	1.1	135,006	1.49	2.92	0.51
$40-50K	2.5	42.7	42.5	11.3	0.9	98,766	1.64	3.09	0.53
$50-70K	1.4	32.7	49.0	16.1	0.8	126,285	1.84	3.17	0.58
$70K ->	0.8	20.1	51.6	26.8	0.8	106,077	2.13	3.41	0.63
N/S	10.2	42.9	31.6	11.0	4.3	150,687	1.42	3.64	0.39
Total	12.1	46.5	30.3	9.3	1.8	1,097,748	1.38	2.79	0.49

Figure E.3 NZ Motor Vehicle Ownership by Income: 1991 Census

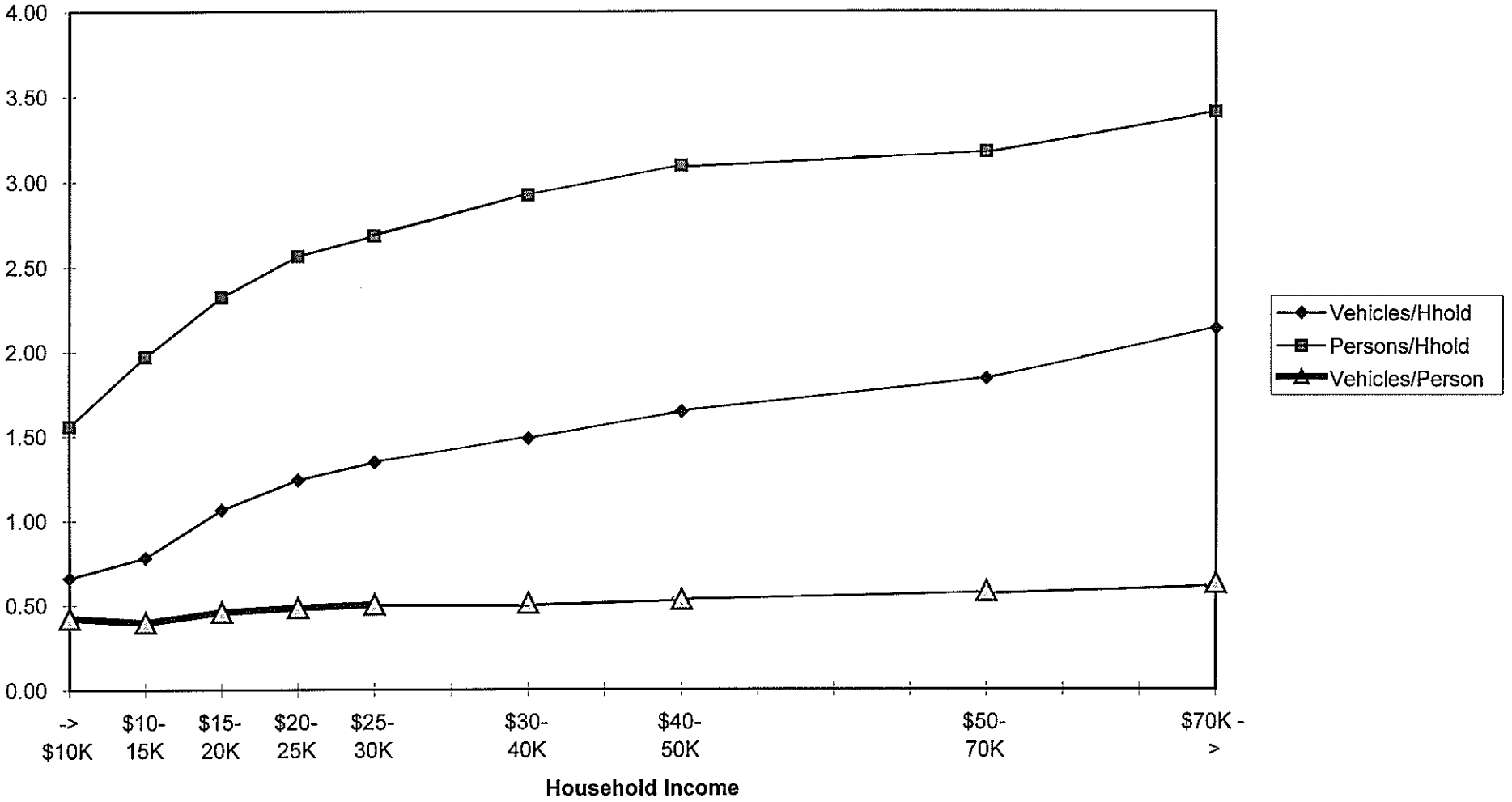


FIGURE E.4: MOTOR VEHICLE OWNERSHIP IN NEW ZEALAND
(One Parent Families With Dependent Children Only)

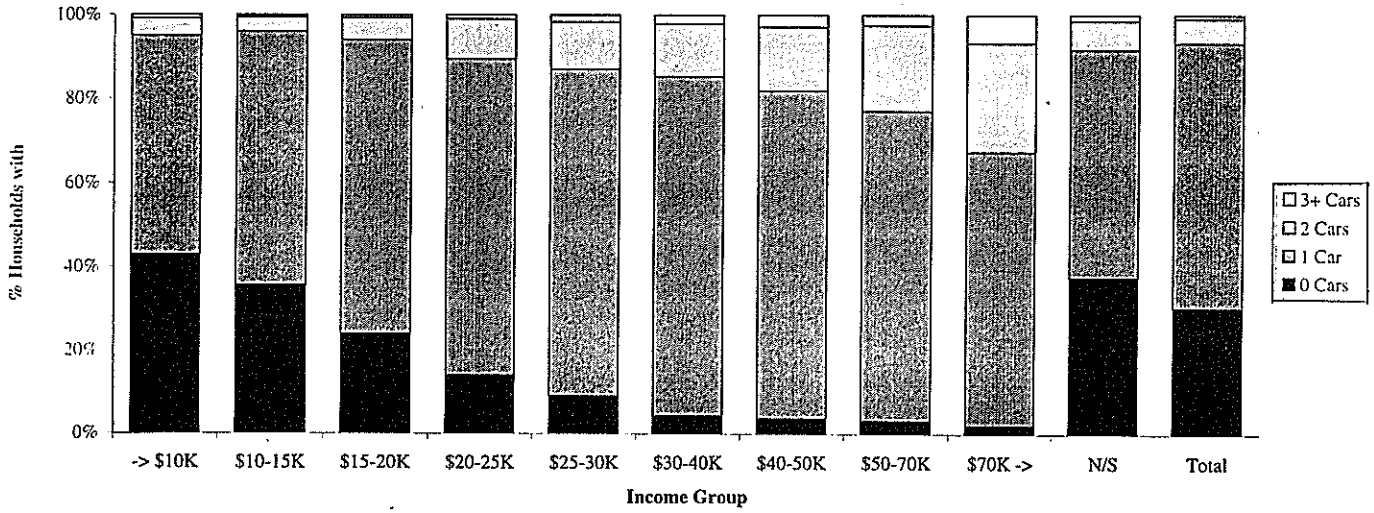


FIGURE E.5: MOTOR VEHICLE OWNERSHIP IN NEW ZEALAND
(One Parent Families With Adult Children With Or Without Dependent Children)

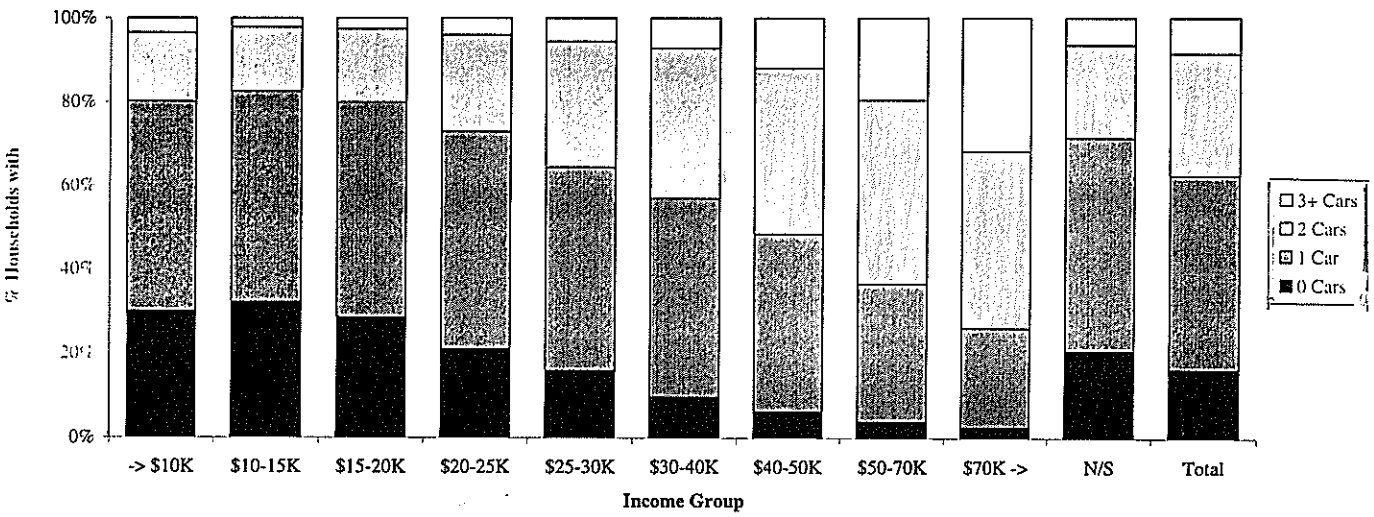


FIGURE E.6: MOTOR VEHICLE OWNERSHIP IN NEW ZEALAND
(Two Parent Families With Dependent Children Only)

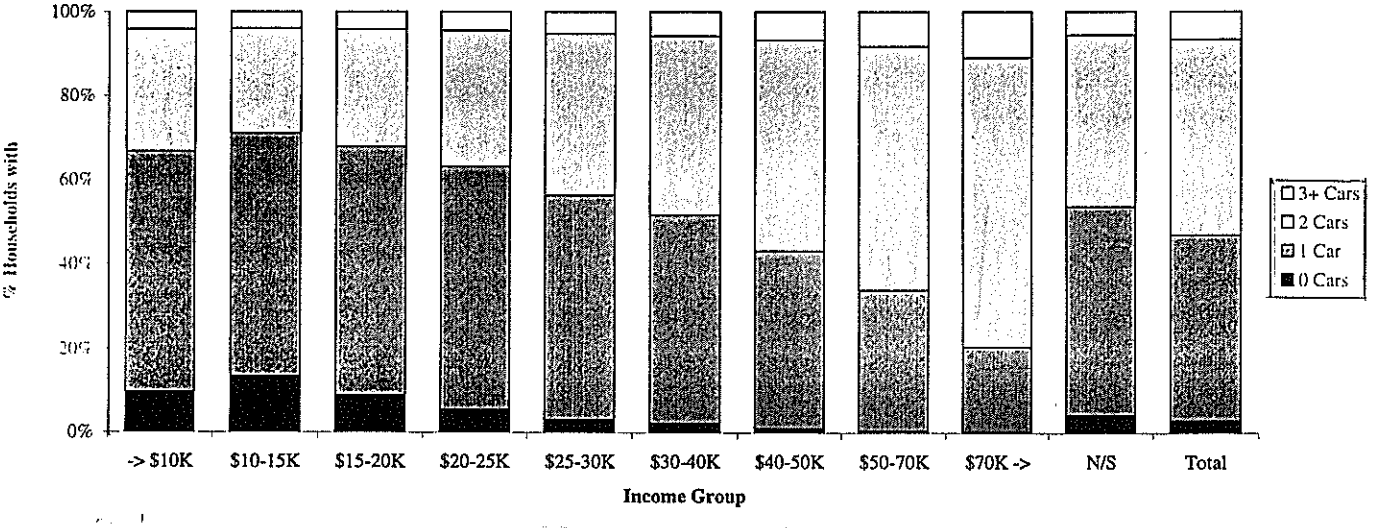


FIGURE E.7: MOTOR VEHICLE OWNERSHIP IN NEW ZEALAND
(Two Parent Families With Adult and Dependent Children)

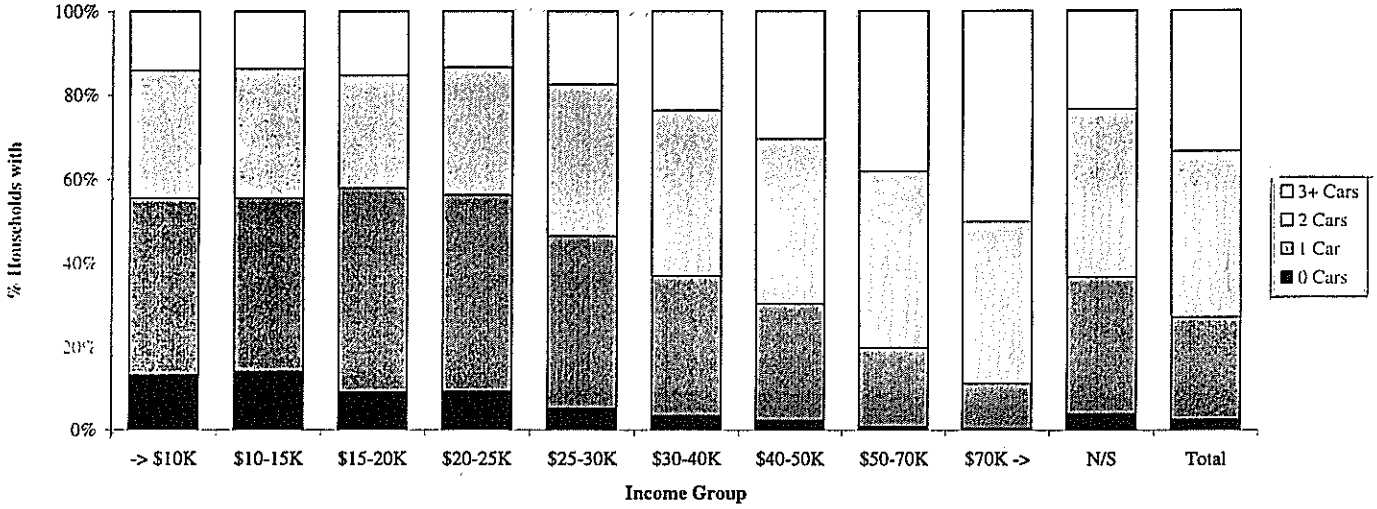


FIGURE E.8: MOTOR VEHICLE OWNERSHIP IN NEW ZEALAND
(Two Parent Families With Adult Children Only)

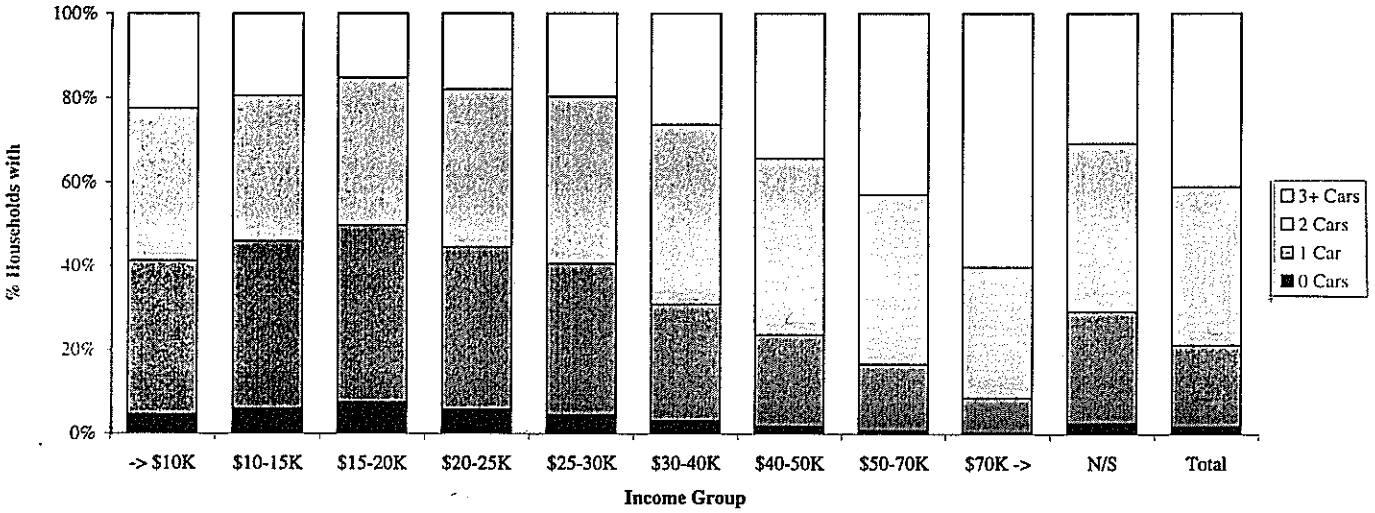


FIGURE E.9: MOTOR VEHICLE OWNERSHIP IN NEW ZEALAND
(Couples Only With One Or Both Retired)

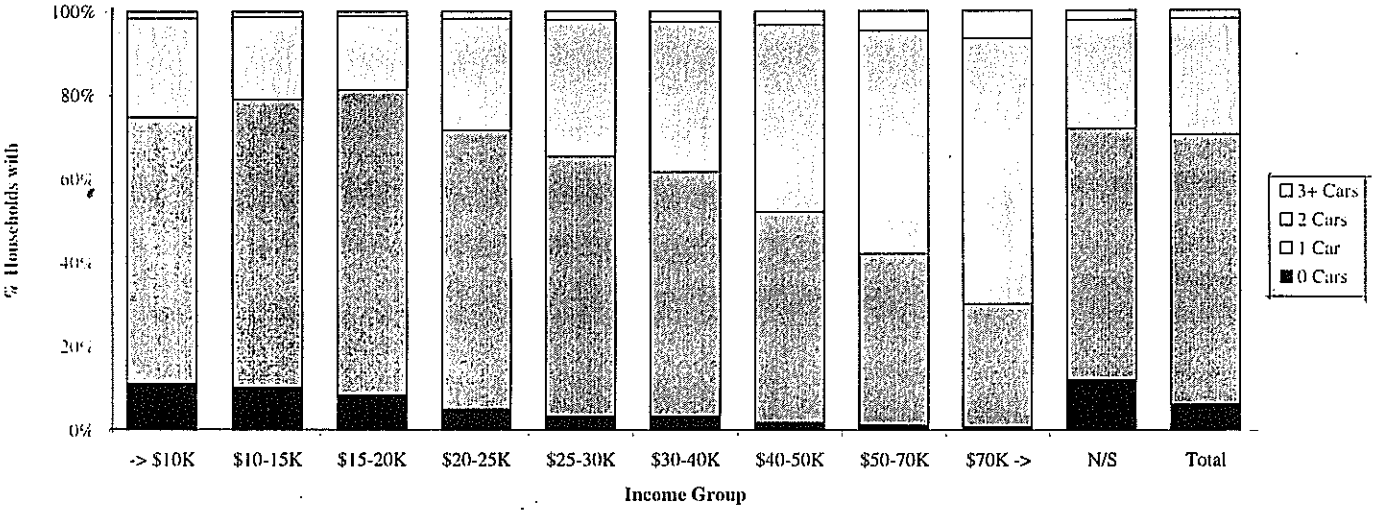


FIGURE E.10: MOTOR VEHICLE OWNERSHIP IN NEW ZEALAND
(Couples Only With Neither Retired)

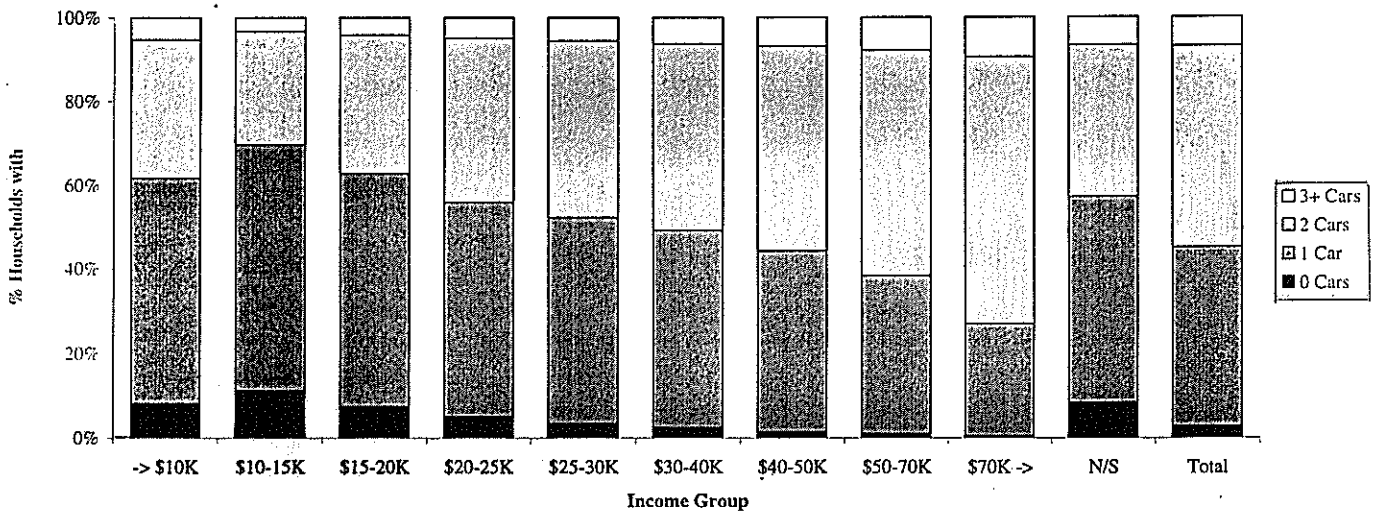


FIGURE E.11: MOTOR VEHICLE OWNERSHIP IN NEW ZEALAND
(Couples Only With Retired N/S)

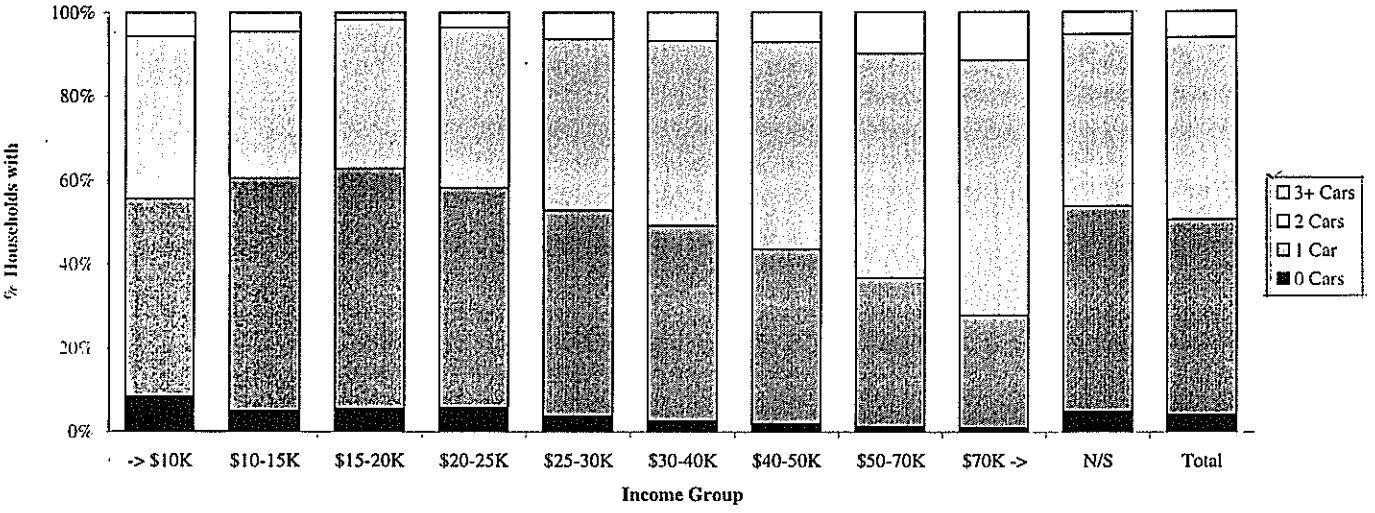


FIGURE E.12: MOTOR VEHICLE OWNERSHIP IN NEW ZEALAND
(Single People Not Retired)

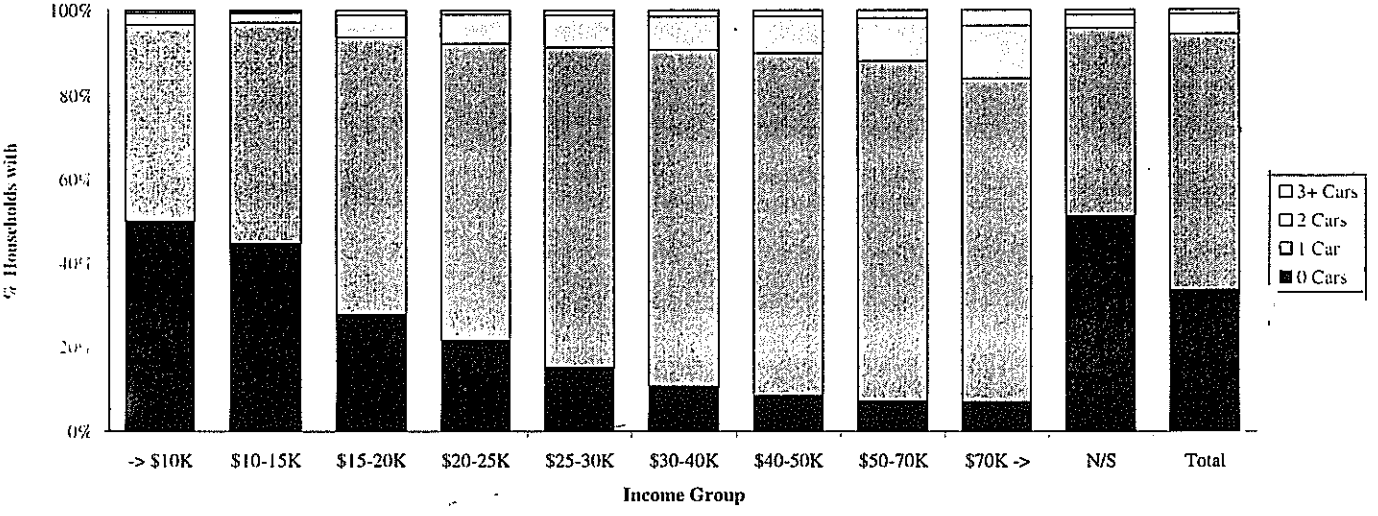


FIGURE E.13: MOTOR VEHICLE OWNERSHIP IN NEW ZEALAND
(Single People Retired)

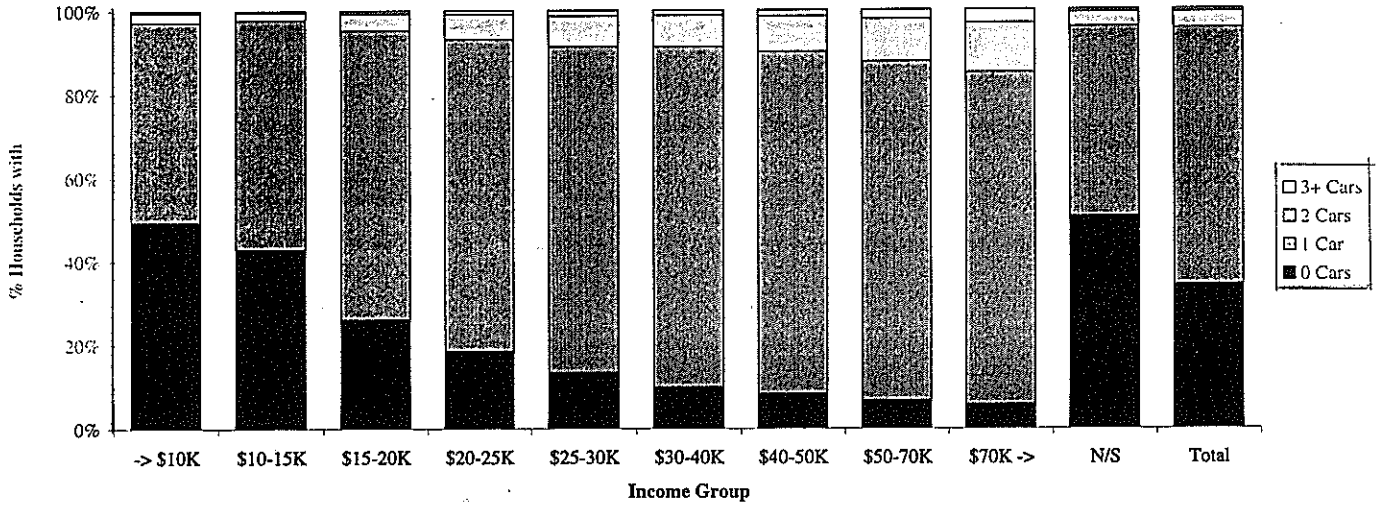


FIGURE E.14: MOTOR VEHICLE OWNERSHIP IN NEW ZEALAND
(Single People Retired N/S)

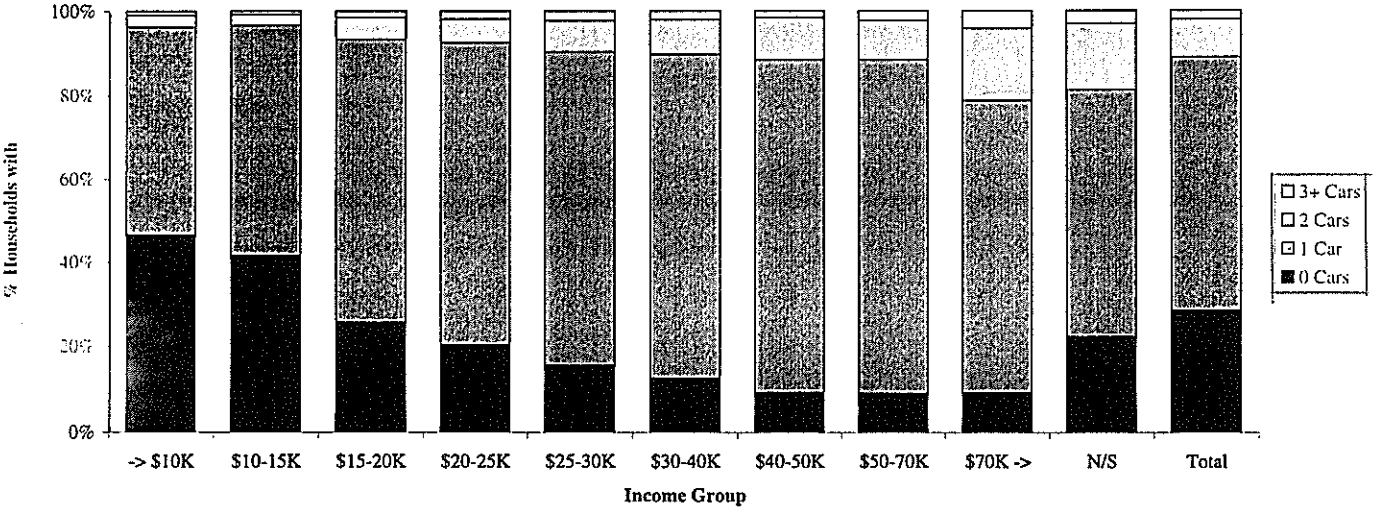


FIGURE E.15: MOTOR VEHICLE OWNERSHIP IN NEW ZEALAND
(Multiple Families)

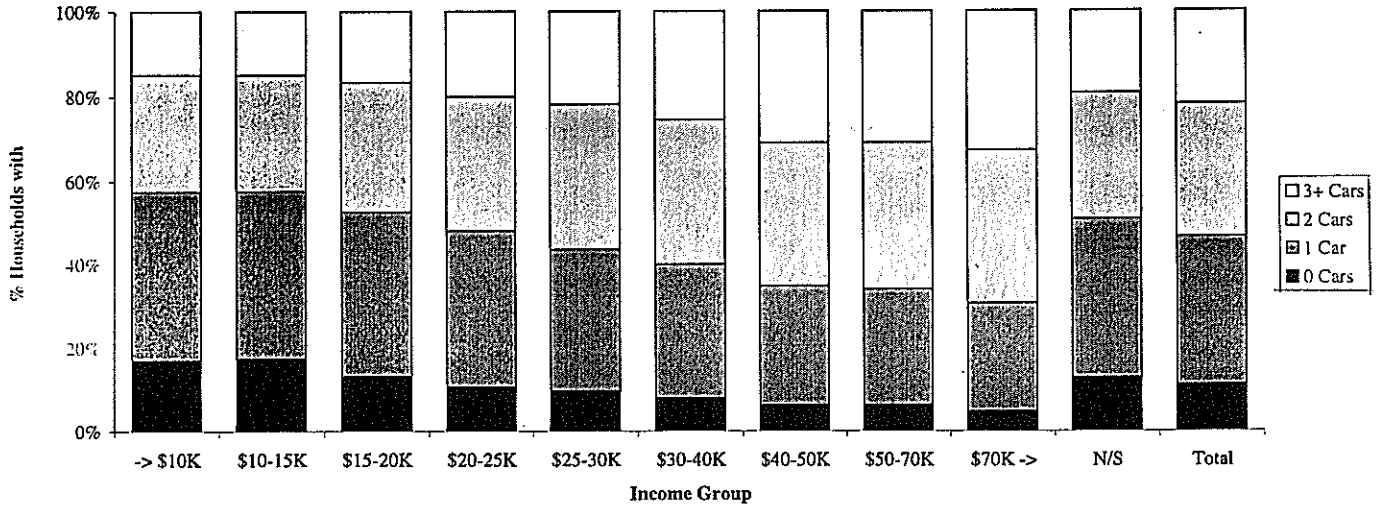
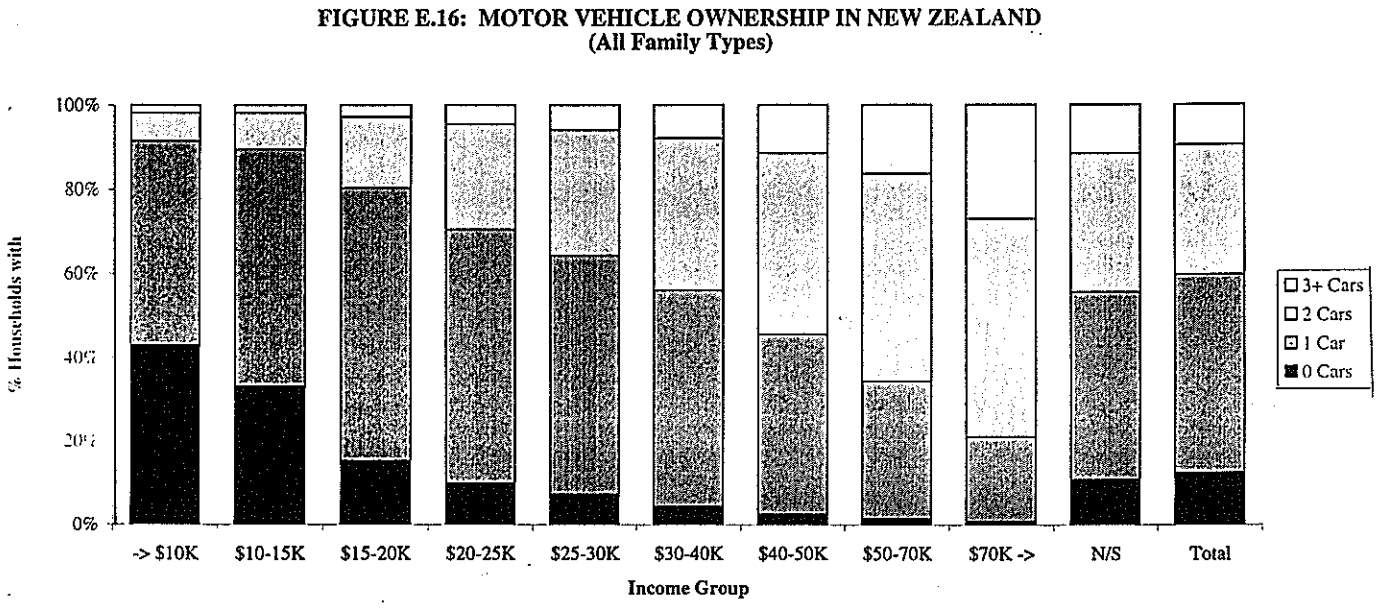


Table E7 Vehicle ownership by household type, from 1991 New Zealand Census.

Family Type	Vehicles/Hhold	Persons/Hhold	Vehicles/Person
One parent families with dependent children only	0.75	2.79	0.27
One parent families with adult children with/without dependent children	1.29	2.59	0.50
Two parent families with dependent children only	1.56	4.11	0.38
Two parent families with adult & dependent children	2.13	4,86	0.44
Two parent families with adult children only	2.31	3.33	0.69
Couples only with one or both retired	1.23	1.98	0.62
Couples only with neither retired	1.59	2.01	0.79
Couples only with retired N/S	1.50	2.01	0.75
Single people not retired	0.72	1.02	0.71
Single people retired	0.69	1.02	0.68
Single people retired N/S	0.78	0.99	0.79
Multiple families	1.68	4.68	0.36
All family types	1.38	2.79	0.49

Figure E16 Vehicle ownership in New Zealand (all family types).



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