Final Report

Vehicle Fleet Emission Screening Programme

Social and Economic Impact Assessment

Phase I

Prepared for

Ministry of Transport

February 2005

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Executive Summary

This report includes the results of research conducted in the first phase of a two-phase study into the social and economic impacts of the proposed vehicle emissions screening programme. It includes preliminary assessments of the likely costs of the programme, including the costs of the test itself, the required repairs and the decision to scrap a vehicle. It examines how the expected costs might affect different household types, depending on levels of income and vehicle dependency. It identifies the likely nature of impacts and the groups most likely to be affected. It also examines policy options that might be used to limit impacts.

Emission Characteristics of Vehicles

A number of conclusions emerge from an analysis of emissions from different types of vehicle.

- For petrol cars, emissions are higher from older cars and those with higher mileage.
- There are very different emission characteristics for diesel-powered vehicles. Notably the pattern of increasing emissions with age does not hold.
- Emission concentrations are lower for vehicles with larger engine sizes. This is a critical issue for the design of testing regimes as this relationship does not follow for emissions mass—it results because of the greater airflow from the exhausts of larger vehicles. For a given concentration, the total amount of pollutant is greater for larger engines.
- There are some reasonably systematic differences in emissions based on model type and country of origin, but New Zealand's car fleet is dominated by Japanese vehicles.

Emission Screening Programmes

Emission screening programmes established in other countries vary with respect to the performance limits or emission cut-points, the network requirements, particularly whether they involve centralised or decentralised facilities or some combination of the two, the type of test employed, the categories and model years of vehicles included and the frequency of testing.

A review of these programmes suggests that:

- test failure rate is expected to increase with vehicle age, reflecting the increased emission rates;
- use of emission limit bands in which there are different requirements for different groups of vehicle, eg on the basis of age, can limit the relationship between failure rate and age, and can reduce the effectiveness of an emission screening programme;
- test costs are likely to be in the order of $20-30, are likely to be lower if a centralised network approach is adopted, but centralised networks will require further travel time on average;
- repair costs following a test failure would be expected to vary widely from close to nothing to over $1,000;

- as a result of the required repair costs, some vehicle owners will choose not to repair their vehicle and face either the cost of a replacement or of managing without a vehicle;
- there will be increased incentives to operate a vehicle without a warrant.

Risks of Failure
Assuming that the rules for the screening programme are established such that the highest emitters are those most likely to fail, this will also be the oldest vehicles.

Older vehicles are most likely to be owned by:

- lower income households; and
- those living outside of Auckland and Wellington, particularly the South Island.

There will be some longer term impact on the vehicle market. More specifically, there will be additional incentives to purchase newer vehicles. This is likely to result in a reduction in the average age of the vehicle fleet and demand is most likely to be met through increases in Japanese imports of mid-age vehicles.

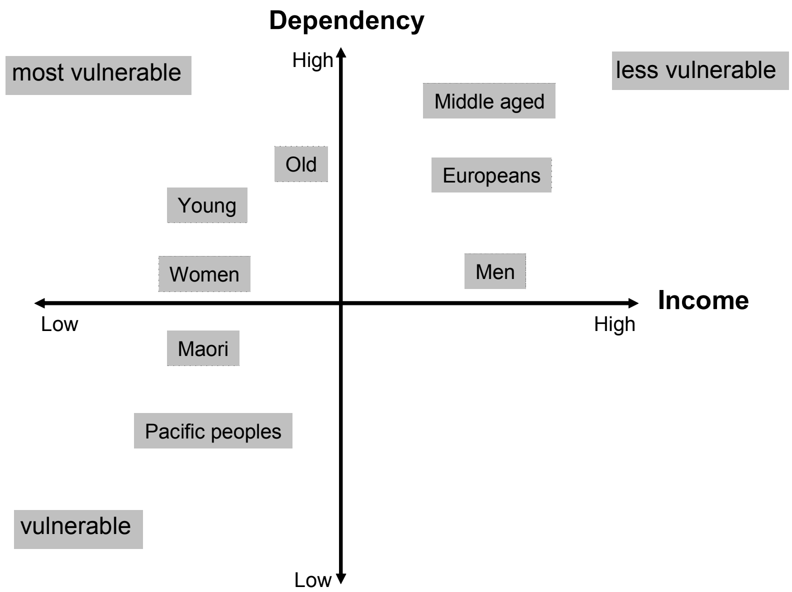
There will be impacts on small garages. On the one hand they are likely to have higher average costs of emission testing, which will make them less competitive than centralised testing stations in providing emission tests. On the other hand, undertaking emission tests is expected to increase the volume of work, which might allow them to cross-subsidise emissions testing.

Consequences of Failure
The impacts of a test failure will vary with the vulnerability of the household; key elements of vulnerability are income and vehicle dependency. Those most at risk are low income households—most likely to own a failing vehicle and least able to pay for the repairs—and those who rely on vehicles for their ongoing participation in work and other activities.

Our analysis suggests that the communities at greatest risk are young and old people, particularly of Maori and Pacific descent (see Figure below). Solo parents are likely to be at particular risk, particularly solo Maori or Pacific Island mothers. They have particularly low average household incomes and relatively high daily living costs. There are also risks for large families, related to the lower levels of disposable income and the number of people affected by a loss of vehicle. Overall, we expect the effects of the policy to be felt most severely in areas where such households are prevalent. Disabled people are also vulnerable because of lower incomes and difficulties in accessing other transport means.

The impacts of having to pay a significant bill for low income households include reductions in spending on other items or descending further into a spiral of debt. Studies on poverty in New Zealand have identified a range of implications for low income households including increased probability of eating poorly, not going to the doctor or dentist, reducing participation in recreational activities, reduced educational opportunities for children and living in unsuitable accommodation.

Figure: Ranking of Communities at Risk



Loss of a car can exclude households from many activities, including health visits, work, shopping, visiting friends and recreation. The difficulties relate particularly to centralised as opposed to distributed facilities. These include hospitals, educational facilities and supermarkets. Some of these issues are compounding problems for low income households:

- avoiding visiting doctors and dentists because of their costs is compounded by travel difficulties;
- reductions in transport options reduce employment opportunities;
- reduced access to supermarkets will often limit access to lower-priced and/or better quality food.

Policy Options

Policy options that might be used to address some of the adverse effects of emissions screening programmes include those that:

- limit the overall costs of the programme, eg through linking emissions screening to use of an economic instrument rather than a regulated standard;
- address the initial effects of the programme, eg through placing a maximum limit on repair costs;
- address vulnerabilities, eg through programmes that address household income or vehicle dependency;
- designing the screening programme in a way that targets particular vehicle types.

Acknowledgements

We are very grateful to the Auckland Regional Council (ARC) and to NIWA for allowing access to their data from the 2003 remote sensing programme. These data have been used in this report for the analysis of the emissions from different classes of vehicle. A preliminary analysis of these data has also been used to assess the expected distribution of the vehicles likely to fail an emissions test.

1. Introduction

1.1. Objectives of the Study

This report includes the results of research conducted in the first phase of a study into the social and economic impacts of the proposed vehicle emissions screening programme[1]. The programme would introduce a requirement for the emissions of vehicles to be tested, most likely as part of the Warrant of Fitness (WoF) or Certificate of Fitness (CoF) test. Vehicles would need to meet certain minimum emission requirements in the same way as vehicles currently have to meet other quality standards as part of the WoF and CoF tests.

The two-phase research project will identify which groups in society are most likely to be affected as a result of the emissions screening programme and the nature of these impacts; it will also analyse policy measures which might be introduced to limit the impacts. The economic component of the impact assessment is limited to an assessment of likely costs falling on specific groups. These numerical assessments are then used as input to an analysis of social impacts, including a comparison of expected costs with disposable income and an assessment of how households and others cope without a vehicle.

The study does not examine wider questions about the efficiency or effectiveness of emission screening in achieving health and environmental outcomes; this is beyond the scope of the study.

1.2. Approach to Social Impact Analysis

There are two main components of the social impact analysis presented here:

- an analysis of income-related effects; and
- social exclusion impacts.

Our analysis undertakes an initial quantitative analysis of the primary initial effects of the emission screening rule. These will be:

- the costs of the test itself;
- the costs of repairing vehicles that fail;
- the costs of preventive measures (eg more regular servicing to reduce the probability of failure);
- the costs of a replacement vehicle where it is not worth repairing, given the value of the vehicle; and/or
- the costs of doing without a vehicle, where the repair costs and the costs of a replacement vehicle are unaffordable.

[1] Ministry of Transport (2004) New Zealand Vehicle Emissions Screening Programme. Discussion Document.

In the first phase of the study we analyse the second order impacts of these effects through a review of relevant literature; this includes an assessment of how households respond to reduced income and specific impacts on social participation as a result of either reduced income or reduced access to a vehicle. In the second phase of the study, we will explore these impacts in greater detail using focus groups.

1.2.1. Income Effects on Wellbeing

As a result of the direct costs of the scheme, as a repair bill, maintenance cost or vehicle purchase price of a replacement vehicle, households and businesses will have reduced disposable incomes. We examine the expected size of these impacts relative to disposable income; we also examine how these income effects might change household expenditure, ie what changes to consumption (or saving) patterns results from these changes to disposable income.

There are two kinds of potential impact:

- Those on health and well-being, eg as a result of reduced expenditure on food, accommodation and so on; and
- Reduced expenditure on activities that involve social participation—these are discussed further below.

In this report we examine literature on demand elasticities to understand how consumption patterns might change, and we examine poverty and other social science literature to estimate some of the impacts on different household types. For the lowest income households, small changes in disposable income can have significant effects on health and wellbeing.

1.2.2. Social Exclusion

Households and individuals may be excluded from participating in some normal activities as a result of either:

- reduced disposable income following payment of repair bills or increased vehicle purchase price (if such an effect results); or
- reduced access to a vehicle where the repair bill required to meet the emission rule is too high and financing a replacement vehicle is unaffordable.

Below we explore the social exclusion issue in greater detail.

The Nature of Social Exclusion

Social exclusion has been widely used in the international academic and policy literature during the last decade. The most significant illustration of its use in the policy field has been through the creation of the Social Exclusion Unit in the UK in 1997. That unit has published a range of work around diverse dimensions of social exclusion, including transport[2]. The concept of social exclusion extends across a wide range of

[2] Social Exclusion Unit (2003) Making the Connections: Final Report on Transport and Social Exclusion. (www.socialexclusionunit.gov.uk)

social and economic policy issues by focusing on multiple dimensions of access to social and economic opportunities. Burchardt takes this definition further: "an individual is socially excluded if he or she does not participate to a reasonable degree over time in certain key activities of his or her society, and (a) this is for reasons beyond his or her control, and (b) he or she would like to participate"[3]. Her definition highlights potentially significant areas of investigation about the relationships between transport and social exclusion.

In their discussion of transport disadvantage and social exclusion in Scotland, Hine and Mitchell draw on work by Church and Frost (1999) to define social exclusion as: "loss of ability (by people or households) to both literally and metaphorically connect with many of the jobs, services and facilities that they need to participate fully in society"[4]. They go on to point out that exclusion results in a declining sense of participation across a number of key areas of daily life. Drawing on other work by Church, they identify a number of categories of exclusion connected to transport. Of these, for the purposes of the present work, geographical exclusion, exclusion from facilities and economic exclusion are the primary relevant dimensions that relate to ways in which lack of access to a motor vehicle has potential exclusionary implications.

Although they have not used the language of social inclusion and exclusion, it is worth noting in this context that the two Social Reports produced by the Ministry of Social Development have drawn on a range of indicators reflecting many of the dimensions of social inclusion and exclusion as part of the framework and structure of its reports. The Minister's quote in the foreword to the first report that: "people in New Zealand want to be included in the fabric of their society, not excluded from it"[5] makes it clear that the Reports have drawn in part at least on the frameworks and theoretical arguments advanced in the discussions on social exclusion in the literature of the last decade.

The term has been the subject of extensive debates in the social policy literature, both as to its definition and meanings and in relation to the implications and consequences of those diverse meanings[6]. Central to those debates in the policy literature is the relationship between the concept of "poverty" and the approach to defining social exclusion. That debate is unimportant for our current purposes and is well summarised by Lister[7]. In her discussion, she notes that whatever the academic debates about the meaning and definitions of social exclusion, it has proven to be a very useful policy concept because it can serve as a: " broad and dynamic integrating framework and focus that "stimulates fresh thinking in the area"[8]. She goes on to note that social exclusion

[3] Burchardt, T. (2000) 'Social exclusion: concepts and evidence' in Gordon, D., Townsend, P. (eds) *Breadline Britain*. Bristol, The Policy Press. p 388

[4] Hine, J., Mitchell, F. (2003) *Transport Disadvantage and Social Exclusion*. Aldershot, Ashgate p5

[5] Ministry of Social Development (2001) *The Social Report*. Wellington, Ministry of Social Development p3.

[6] Those debates are well reviewed by: (1) Lister, R. (2004) *Poverty*. Cambridge, Polity Press; (2) Hill, J., Le Grand, J., Piachaud, D. (eds) (2002) *Understanding Social Exclusion*. Oxford, Oxford University Press ; (3) Levitas, R. (1998) *The Inclusive Society?* Basingstoke, Macmillan ; and (4) Levitas, R. (2000) 'What is social exclusion?' in Gordon, D., Townsend, P. (eds) *Breadline Europe*. Bristol, Policy Press

[7] Lister (op cit)

[8] Lister (op cit) p97

allows for a wider policy focus, noting that one of the wider areas of focus that is encompassed by social exclusion is transport, an area that is seldom included in discussion of social policy.

The analysis in this report explores the expected social exclusion impacts of the emissions screening programme. In this initial phase this is undertaken largely through the literature review. In the next phase it will be explored in more detail via focus groups, and this report helps to provide better targeting of those groups.

1.3. Content and Structure of Phase I Report

This Phase I report includes preliminary assessments of the likely costs of the programme, including the costs of the test itself, the required repairs and the decision to scrap a vehicle. It examines how the expected costs might affect different household types and other vehicle owners, depending on levels of income and vehicle dependency. It identifies the likely nature of impacts and the groups most likely to be affected. It also examines the way in which different design options for the screening programme will affect programme costs.

The work for the first phase is based on the following inputs:

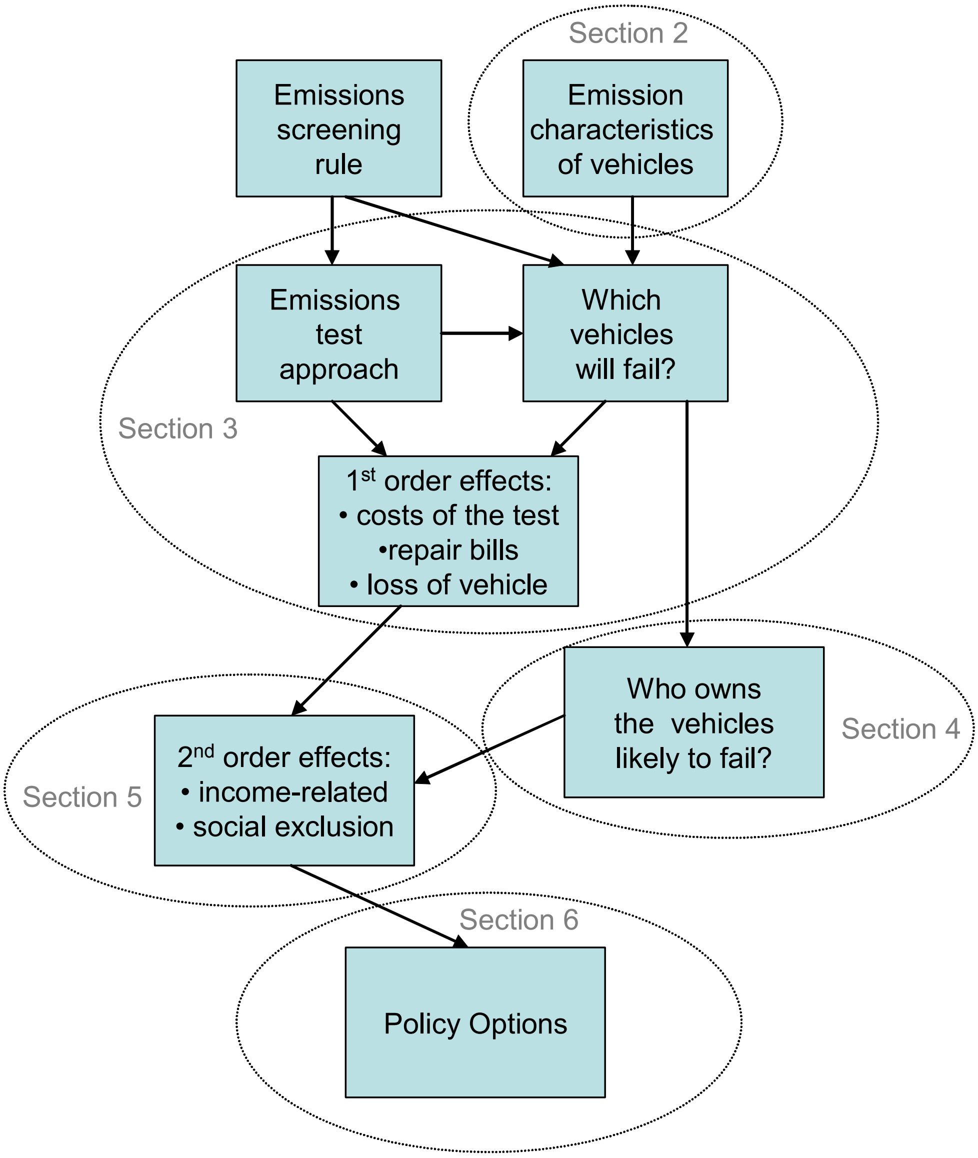
- Literature review of overseas programmes, their effects and mitigation policies;
- A preliminary analysis of the results of a remote sensing programme organised by the ARC and NIWA that measured vehicle emissions in the Auckland region;
- Interviews with vehicle industry representatives.

Figure 1 below sets out the contents of this report and how they fit together in identifying impacts and policy options. At this stage, the emissions screening rule has not been defined. This is an important piece missing from the analysis as it is used, alongside information on the emission characteristics of vehicles, to identify those vehicles that are likely to fail a test. We are expecting that this will be specified by MOT during Phase II of this project.

The contents of this report include:

- Section 2—Emission Characteristics of Vehicles—identifies which are the worst emitters;
- Section 3—Emission Screening Programmes—assesses different approaches to screening vehicles based on international experience, examines which vehicles are likely to fail on the basis of simple assumptions about the way that a test might be specified, and estimates the first order effects on failing vehicles, particularly the costs of repairs;
- Section 4—Risks of Test Failure—identifies the characteristics of households likely to own a vehicle that fails;
- Section 5—Consequences of Failure—examines the second order impacts on households including income effects and impacts on social inclusion; and
- Section 6—Policy Options—identifies a number of policy options that might be used to limit the impacts—these will be analysed in more detail in the next Phase.

Figure 1: Contents of Phase I Report



In the next phase of this project, we expect to:

- have a clear understanding of the emissions screening rule, including the pollutants that are covered and the levels of allowable emissions for specific types of vehicle;
- include further information on the emission characteristics of vehicles as a result of output from the pilot programme;
- provide additional information on first order effects, including those on the vehicle market;
- provide a detailed assessment of the location and socio-economic characteristics of the owners of vehicles that are likely to fail the test;

- undertake focus group analysis with key informants to obtain a better understanding of the expected social impacts; and
- identify and analyse a range of different policy options.

2. Emissions Characteristics of Vehicles

2.1. Objectives of the Section

The first step in identifying the impacts of the programme is to identify the emission characteristics of vehicles. This is done to categorise those likely to be high emitters and those likely to fail an emission test. The Ministry of Transport (MoT) has instigated a pilot testing programme that is using a number of methods to measure the emissions of vehicles throughout the country. This is expected to provide detailed information on the emission characteristics of vehicles. In the absence of the results of this programme at this stage in the project, we have used the results of a study undertaken in 2003 that used remote sensing to analyse the emissions from vehicles in the Auckland region[9]. Using these data allows us to make some initial conclusions prior to receiving the results of the pilot testing programme and enables earlier planning of the second phase of the work.

The objective of this section is to explore the relationship between emissions and vehicle types. It does so in very broad terms on the basis of limited information and analysis. The type of analysis used in this section will be undertaken in considerably greater detail in Phase II of the project, once the results from the pilot programme are available. The results presented here are used in the next section to suggest which types of vehicle are likely to fail an emissions test. The results also provide information relevant to decisions on how rules for a screening test might be established. In this section we analyse emissions against:

- year of manufacture;
- mileage
- engine size;
- model; and
- country of origin.

The emissions of interest are carbon monoxide (CO), hydrocarbons (HC) and nitrous oxides (NO).

The analysis provides greater detail regarding the characteristics of petrol vehicles than it does for diesel vehicles. Generally diesel vehicles show much less emission differentiation across categories. Diesels represent 18% of the total vehicle fleet, including 8% of the passenger car fleet and 62% of commercial vehicles[10].

The data used in this section is sourced from the Auckland remote sensing programme. The limitations of remote sensing versus other test methods are discussed in Section 3.

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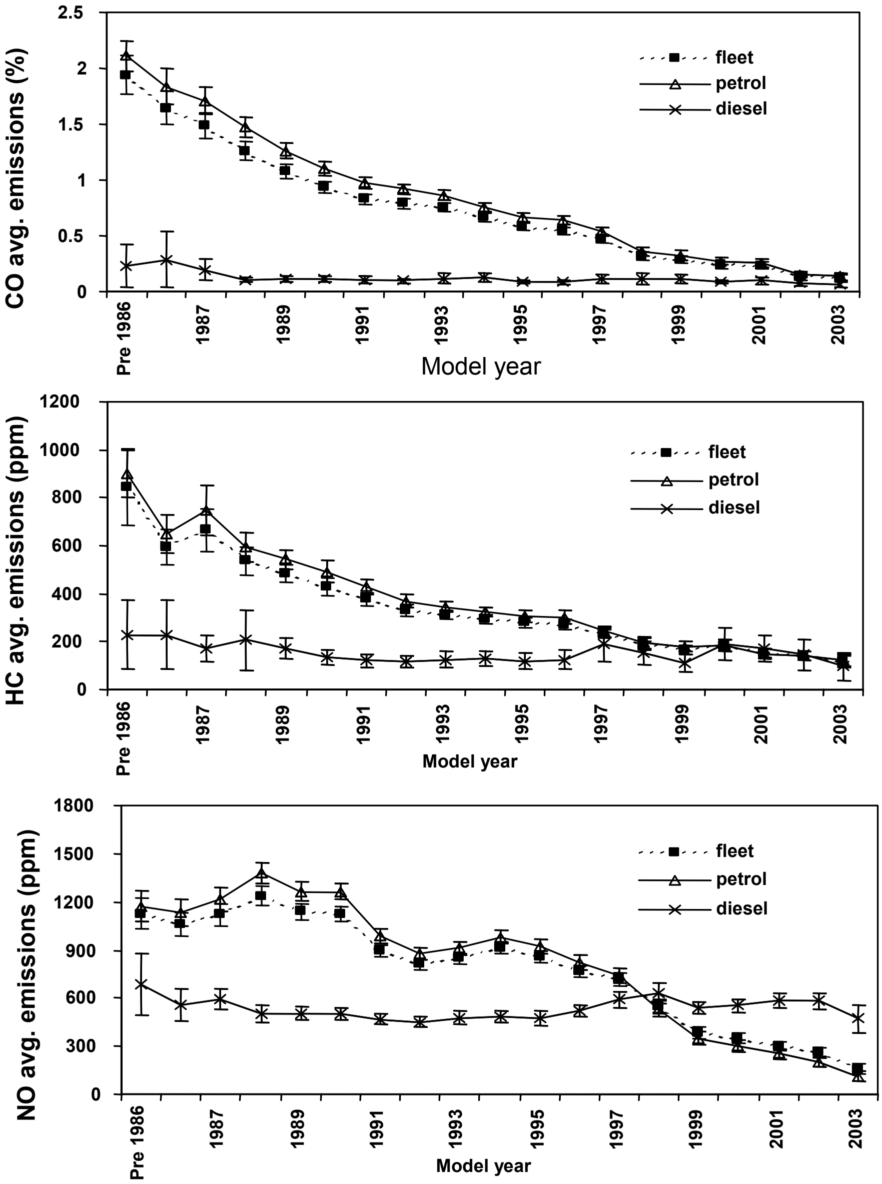
[9] Fisher GW, Bluett J, Xie S and Kuschel GI (2003) On-road remote sensing of automobile emissions in the Auckland region: Analysis and presentation of the full data set. NIWA Report AK2003-93. 84 p.

[10] LTNZ data

2.2. Year of Manufacture

The average CO, HC, and NO emissions by model year are shown in Figure 2. Vehicles of 1985 and older were grouped together because of the small sample of older vehicles. For the total fleet, a steady decrease of average CO and HC emissions with newer vehicles is observed. Average NO emissions also demonstrate a general downward trend but show relatively large decreases around 1991 and 1998. Petrol vehicles show the same pattern of emissions variations as the total fleet, but diesel vehicles do not demonstrate any obvious upward or downward trends in emissions with age.

Figure 2 Variations of average CO, HC, and NO emissions with vehicle model year for the total fleet, petrol vehicles, and diesel vehicles. Error bars represent the 95% confidence intervals for the average values



2.3. Mileage

A comparison was made between vehicles that had relatively low and relatively high mileages.

2.3.1. Petrol Fuelled Vehicles

To minimise the effect that variation of vehicle age has on emissions, an analysis was performed on vehicles manufactured in each of the years, 1992, 1993 and 1994. The result of the comparison between high and low kilometre vehicles manufactured in 1994 is presented here. The average odometer reading of the 2,700 vehicles within this subset of the sample fleet was 124,000 km. The 1994 petrol-fuelled vehicle fleet was disaggregated into quartiles according to the distances they had travelled. The emissions from vehicles with odometer readings in the upper quartile (160,000 km) were compared to vehicles in the lower quartile (97,000 km). The difference in emissions of CO, hydrocarbons, NO and opacity from high and low kilometre vehicles are shown in Figure 3.

Figure 3 Comparison of the 1994 sample fleet average CO, HC, NO and opacity emissions for petrol vehicles with high and low odometer readings

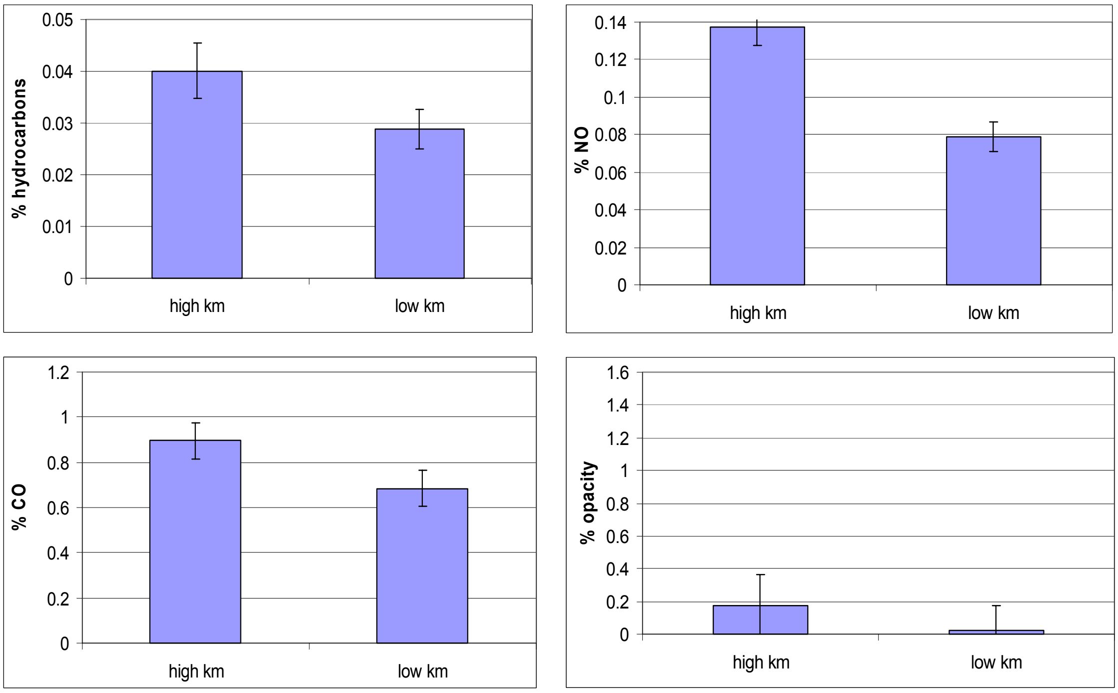


Figure 3 shows that the 1994 petrol fleet average emissions of CO, hydrocarbons and NO are statistically significantly lower for vehicles that have travelled less distance and that opacity[11] is also lower, but not significantly so. A comparison of emissions from

[11] Opacity is a measure of the particulate emissions, but is not necessarily correlated with PM10. The measurements made in this initial remote sensing programme for opacity were preliminary and subject to greater uncertainty than the other emissions measurements. However it is a suitable first order indicator of particulate pollution, and is similar to the opacity measurements made as part of emissions testing programmes in other parts of the world

high and low kilometre vehicles manufactured in 1992 and 1993 yielded the same conclusions: high kilometre vehicles discharge significantly more CO, hydrocarbons and NO; and opacity appears to be higher for high kilometre vehicles, but the sampling uncertainty is large.

2.3.2. Diesel Fuelled Vehicles

The average odometer reading of the 2,600 vehicles within the subset of model year 1990-1995 was 165,000 km. The 1990 to 1995 diesel fuelled vehicle fleet was disaggregated into quartiles according to the distances they had travelled. The emissions from vehicles with odometer readings in the upper quartile (217,000 km) were compared to vehicles in the lower quartile (128,000 km). The emissions of CO, hydrocarbons, NO and opacity from high and low kilometre vehicles are compared in Figure 4.

Figure 4 Comparison of the 1990-1995 sample fleet average CO, HC, NO and opacity emissions for diesel vehicles with high and low odometer readings

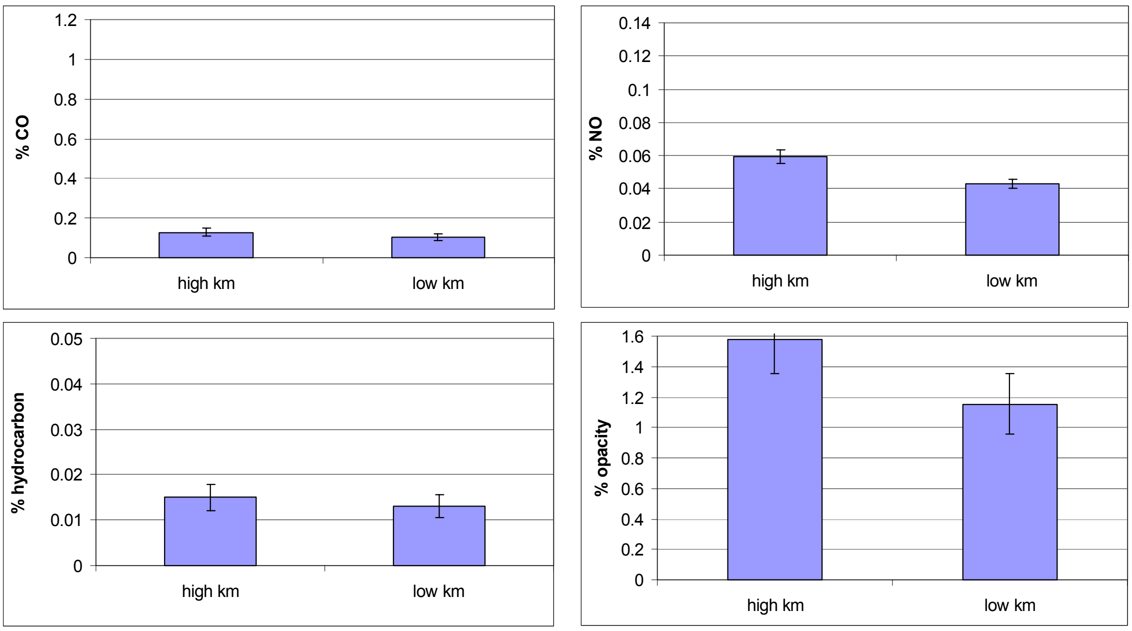


Figure 4 shows that the 1990-1995 diesel fleet average emissions of CO, and hydrocarbons were not significantly different for vehicles with high and low odometer readings and that the 1990-1995 diesel fleet average emissions of NO and opacity are higher for vehicles that have travelled greater distances. Opacity measurements for diesels are very much greater than those for petrol vehicles (same scales on Figure 3 and Figure 4).

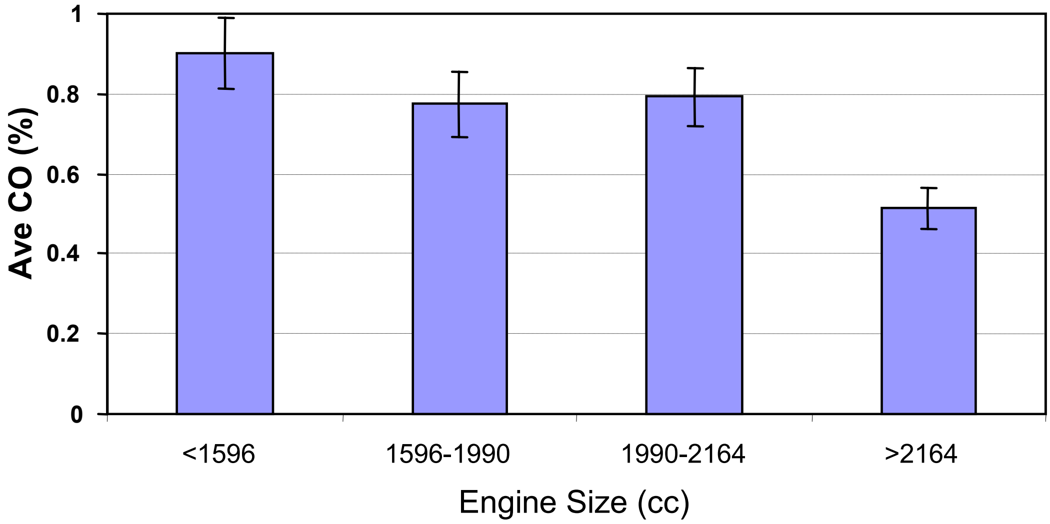
2.4. Engine Size

A comparison of emissions was made between vehicles that had relatively small and large engine sizes. The effects of engine sizes on emissions have been analysed for CO emissions from petrol vehicles. To minimise the effect that variation of vehicle age has on emissions, an analysis was performed on vehicles manufactured in 1994. The 1994 petrol fuelled vehicle fleet was disaggregated into quartiles according to the engine sizes. CO emissions from different engine sizes are shown in Table 1 and Figure 5. The results show that average CO emission from small engines (<1596 cc) is higher than from large engines (>2164 cc).

Table 1 CO emissions of different engine sizes for 1994 petrol vehicles

Category	Vehicle number	Engine size (litre)	Average engine size (litre)	Average CO emission (%)
1st quartile	693	<1596	1481	0.90
2nd quartile	691	1596-1990	1830	0.77
3rd quartile	779	1990-2164	2028	0.79
4th quartile	610	>2164	3084	0.51

Figure 5 Variations of average CO emissions with vehicle engine size for 1994 petrol vehicles. Error bars represent the 95% confidence intervals for the average values



2.5. Model

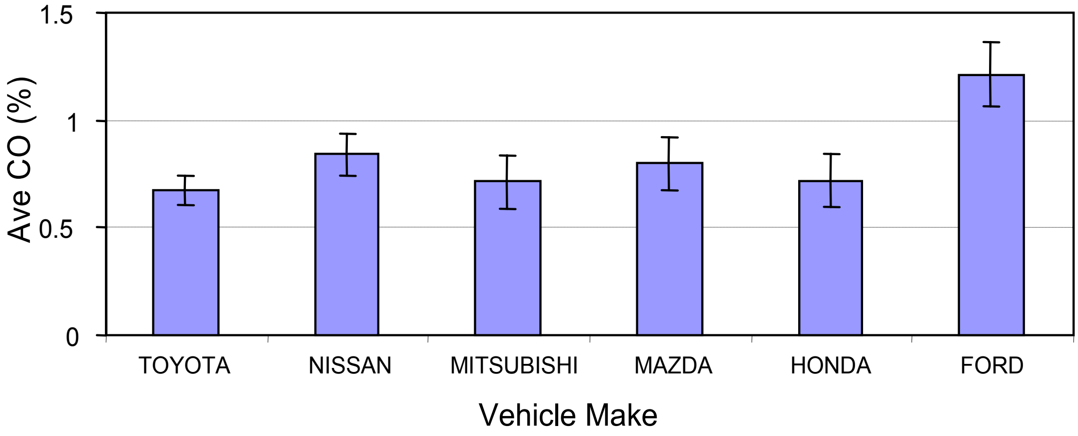
A comparison of emissions was made between different vehicle models. The effects of vehicle model on emissions have been analysed for petrol vehicles and for CO emissions. To minimise the effect that variation of vehicle age has on emissions, an analysis was performed on vehicles manufactured in 1994. The 1994 petrol fuelled vehicle fleet was disaggregated according to model. CO emissions from the six most popular models are shown in Table 2 and Figure 6. The results show that average CO emission from Fords is higher than those from the other five most popular models (Toyotas, Nissans, Mitsubishis, Mazdas and Hondas).

Note that this analysis does not reflect country of origin, as most Fords are made in Japan.

Table 2 CO Emissions of Different Vehicle Models for 1994 Petrol Vehicles

Model	Vehicle number	Average CO emission (%)
Toyota	665	0.67
Nissan	459	0.84
Mitsubishi	345	0.72
Mazda	295	0.80
Honda	280	0.72
Ford	239	1.21

Figure 6 Variations of average CO emissions with vehicle make for 1994 petrol vehicles. Error bars represent the 95% confidence intervals for the average values



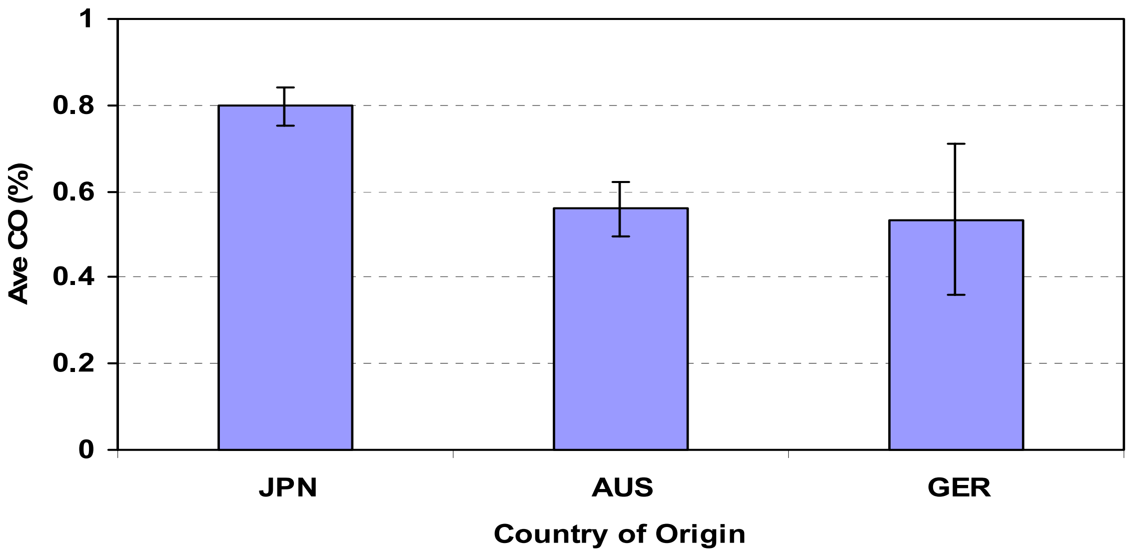
2.6. Country of Origin

A comparison of emissions was made between different countries of origin. The effects of country of origin on emissions have been analysed for petrol vehicles and for CO emissions. To minimise the effect that variation of vehicle age has on emissions, an analysis was performed on vehicles manufactured in 1994. The 1994 petrol-fuelled vehicle fleet was disaggregated according to country of origin. CO emissions from the three most popular sources are shown in Table 3 and Figure 7. The results show that average CO emission from Japan is higher than those from the other two most popular sources (Australia and Germany).

Table 3 CO emissions of different country of origin for 1994 petrol vehicles

Country of Origin	Vehicle number	Average CO emission (%)
Japan	2287	0.80
Australia	254	0.56
Germany	116	0.53

Figure 7 Variations of average CO emissions with country of origin for 1994 petrol vehicles. Error bars represent the 95% confidence intervals for the average values



2.7. 'Gross Emitters' with model year and mileage

Distribution of the 'Gross Emitters' (the highest 20% emitters) with model year and mileage is shown in Table 4.

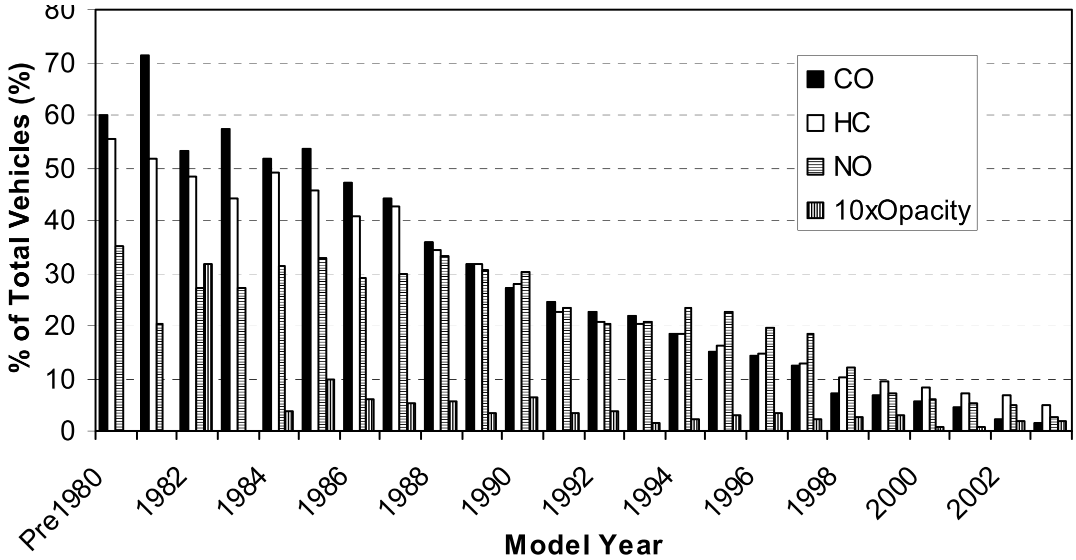
Table 4 Comparison between the 20% dirtiest vehicles (100 dirtiest vehicles for opacity) and the whole fleet

Pollutant	CO	HC	NO	Opacity	Whole fleet
Number of vehicles in subset	7507	7444	6507	100	34500
Contribution of top 20% vehicles to total emissions	73%	68%	63%		
Average model year	1991	1991	1992	1992	1994
Mileage ('000s km)	151	139	142	165	125

2.7.1. Age

The age of vehicles, as defined in the data, is not always the same thing. For imported second hand vehicles, it includes a mix of actual year of manufacture, model year and year of first registration. This is particularly so for vehicles post 1996. Despite these considerations, older vehicles are more likely to be high emitters than newer ones. The average model year of high emitters is 1991-1992, compared to 1994 for the whole sample fleet. Figure 8 shows the fraction of high emitters in each model year, demonstrating an increasing proportion of high emitters with older vehicles.

Figure 8 The fraction of high emitters (20% dirtiest vehicles) in each model year, expressed as a percentage for CO, HC, and NO but as numbers in a thousand for opacity

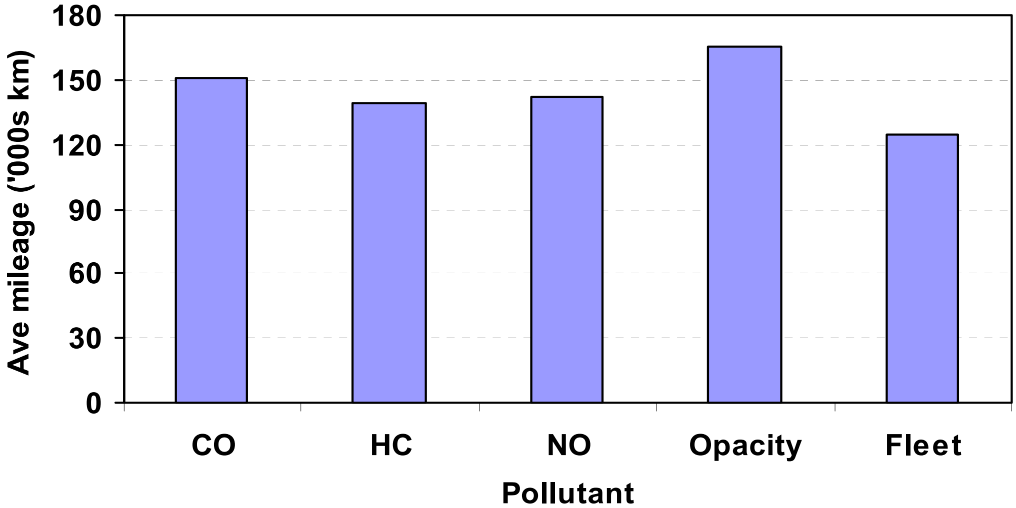


In conclusion, for petrol vehicles, older vehicles are more likely to be high emitters than newer ones.

2.7.2. Mileage

Mileage data is not regarded as accurate, because of odometer tampering. However, some trends can be seen in the data. The average cumulative mileage of high emitters is higher than the whole fleet average, particularly for high opacity vehicles. Figure 9 shows the average cumulative mileage of high emitters (20% dirtiest vehicles) for CO, HC, NO and opacity, in comparison with the whole fleet.

Figure 9 The average cumulative mileage of high emitters (20% dirtiest vehicles) for CO, HC, NO and Opacity, in comparison with the whole fleet



The average cumulative mileage of high emitters is higher than the whole fleet average, indicating that high mileage vehicles are also likely to be higher emitters.

2.8. Conclusions

This section identifies the characteristics of vehicles that would be expected to have high emissions. Combined with information in the next section on the nature of testing programmes, it provides a provisional means for identifying which vehicles are likely to fail an emission test. This in turn allows us to provide a categorisation of the owners of vehicles likely to fail.

There are a number of conclusions emerging from the limited analysis of emissions versus vehicle characteristics provided here:

- For petrol cars, emissions are higher from older cars and those with higher mileage. For practical reasons, year of manufacture is easier to measure than mileage. Odometer readings can be tampered with and the reading available is that of the last Warrant of Fitness only.

- There are very different emission characteristics for diesel and petrol-powered vehicles. Notably the pattern of increasing emissions with age does not hold for diesel vehicles.

- Emission concentrations are lower for vehicles with larger engine sizes. This is a critical issue for the design of testing regimes as this relationship does not follow for emissions mass—it results because of the greater airflow from the exhausts of larger vehicle. The total amount of pollutant is greater for larger engines.

- An analysis of model type and origin shows some differences but as over 90% of the New Zealand fleet comes from Japan, the sample size for those of other origin may become too small in some regions; origin does not become a useful differentiating characteristic.

2.9. Work in Phase II

The analysis in Phase II of the project will provide a much more detailed assessment of vehicle emission characteristics. Vehicles will be categorised to estimate likely emission rates and to associate these vehicle types to a geographical area. The most useful parameters for petrol vehicles appear to be:

- vehicle age;
- fuel; and
- engine size.

Diesel vehicles are less easily differentiated.

The emission characteristics of these groupings of vehicles will be used, alongside the LTNZ vehicle database and a draft emissions rule, to identify the location of the vehicles most likely to fail the emissions test. Expected failure rates will be used, in association with area-specific socio-economic data, to identify the household types most likely to have a vehicle that fails.

3. Emission Screening Programmes

This section discusses the elements of the proposed emission screening programme. It identifies:

- expected costs, both of the test and the required repairs;
- the elements of the design which are likely to have material impacts on these costs; and
- which vehicle types are most likely to fail an emissions test.

The assessment is provisional at this stage. MOT has not identified the type of screening test that will be used in New Zealand; nor has it identified the screening rule. It means that we are uncertain of the test costs that will apply and the vehicles most likely to fail. The information in this section will be updated in Phase II of this project as policy decisions are made. At this stage it provides information about likely costs and thus the 1st order effects of the proposed screening programme.

3.1. Emissions Screening Programme

The different proposed approaches to emissions testing are discussed in the public discussion document on the emissions screening programme[12]. The key elements of the programme include:

- performance limits;
- network requirements;
- test type requirements;
- vehicle coverage; and
- frequency.

In this section we briefly discuss the implications of these choices and the assumptions used for analysis in this report.

3.1.1. Performance Limits

Performance limits are the emission standards or cut-points that define whether a particular class of vehicle passes or fails the test. There are two key elements:

- stringency; and
- banding— use of different emission standards for different vehicle bands, differentiated, eg by model year.

The stringency of these performance limits will affect the number of vehicles that fail. In analysis of the emissions data we will examine the implications of altering the stringency in a way that achieves a range of fail rates. Limits might be set in terms of concentrations in the exhaust gas or as total mass emissions.

[12] Ministry of Transport (2004) New Zealand Vehicle Emissions Screening Programme. Discussion Document.

Banding is an important issue and one that complicates the analysis. The simplest way to develop an emissions limit is to have a single standard or cut-point that applies to all vehicles. Given the relationship between vehicle age and emissions[13], the main effect will be to force early retirement of old vehicles. Whereas this might be the most cost-effective approach to limiting emissions, arguably it is unfair on those that have bought vehicles in expectation of a longer life. Also it may not provide incentives to maintain relatively new vehicles, which could perform much better. The unfairness argument is not one that generally is applied to other areas of environmental policy, eg reducing emission standards for older plants; rather standards are used to drive investment in new plant. The efficiency or otherwise of this programme is not the subject of this analysis.

For New Zealand the issue of banding is important also in the context of the vehicle market and this issue is addressed in more depth in Section 4.6. Many other countries have introduced banded systems of emission limits for in-use screening. However, largely these countries restrict second hand car imports. In contrast, car sales in New Zealand are dominated by second hand imports. The introduction of bands may provide incentives for imports aged at the beginning of these banded categories. We explore these issues on the vehicle market below.

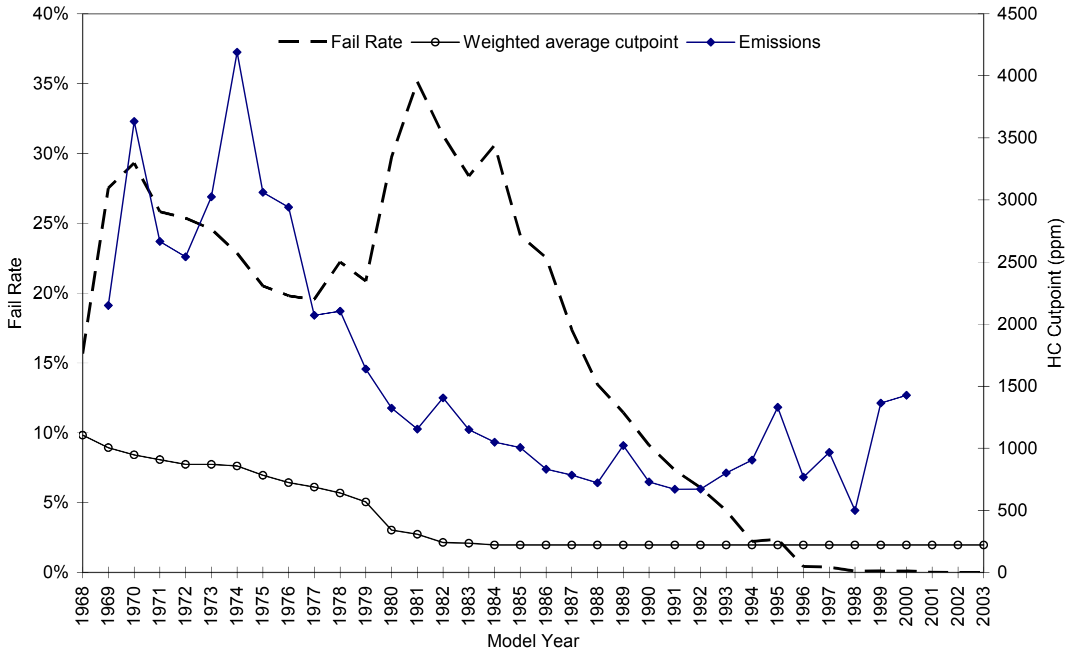
Figure 10 illustrates the results of banding with data from the Northern Kentucky programme for petrol vehicles. The graph shows test fail rates that increase with newer model years up to a peak in 1981 as the cut-points[14] increase in stringency. From 1984 when the cut-points are the same each year, the fail rates fall with newer model years. Figure 10 also plots initial emissions revealed in the test. Very largely these fall over time. Figure 11 illustrates failure rates with model year for diesel vehicles. Failure rates are low, and the number of vehicles is very small in some model years, but it too shows failure rates that fall with increasingly recent vehicles.

The shape of the fail rate curve is similar to that seen in California (Figure 12) and Arizona (Figure 13).

[13] This relationship applies to petrol vehicles but is not obvious for diesel vehicles

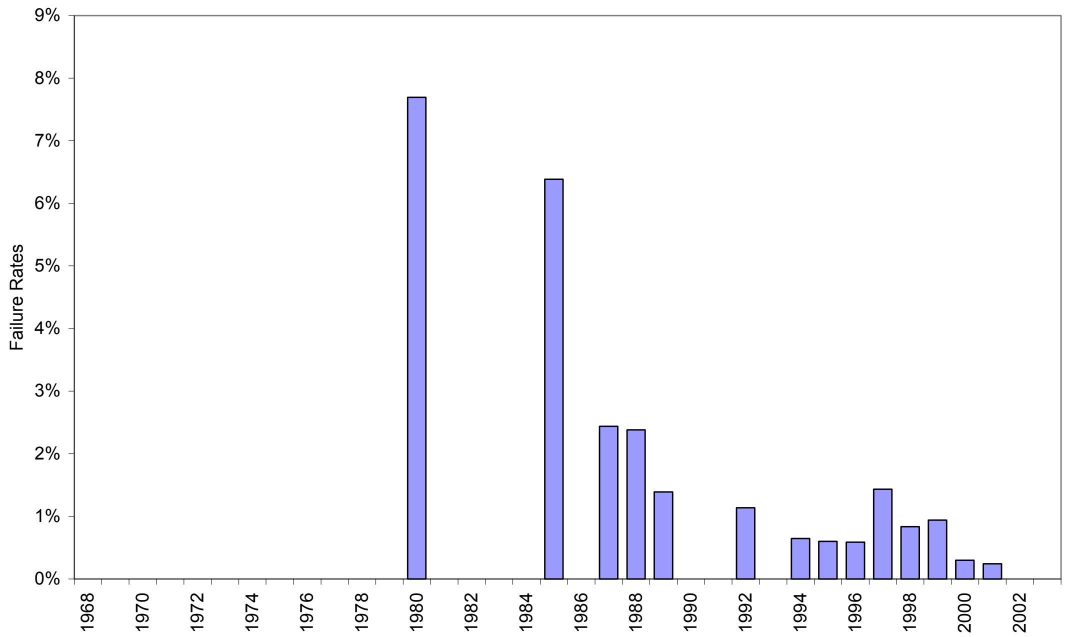
[14] The cut-points in the graph are a weighted average of four cut-point series for different vehicle types. The cut-point is weighted by proportion of total vehicles tested that fall in each category.

Figure 10 Results of Kentucky Emission Test Programme (Petrol Vehicles)



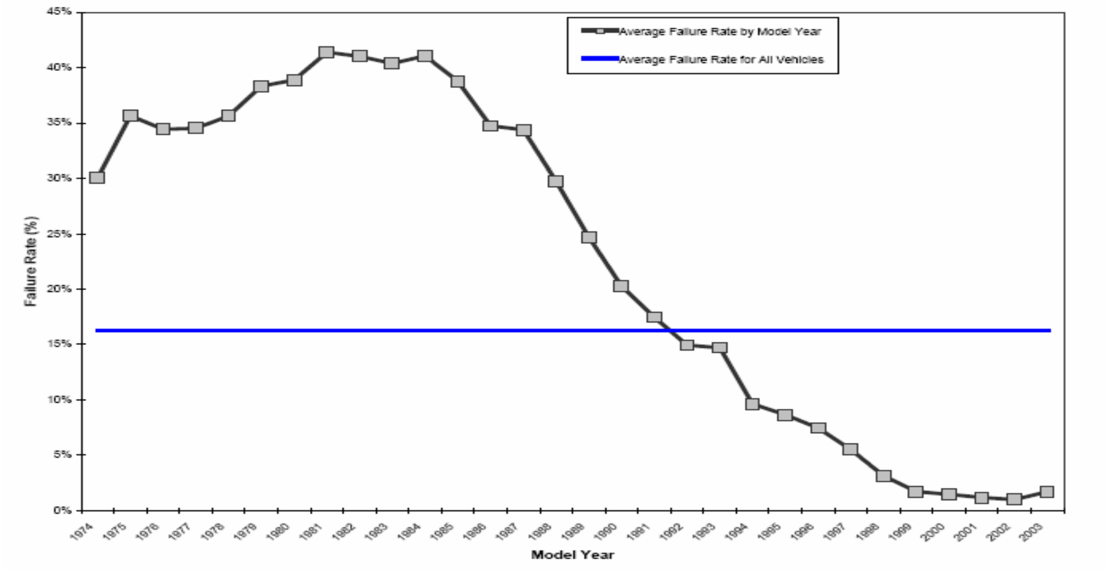
Source: Kentucky Division for Air Quality (2004) Northern Kentucky Emissions Check 2003 Annual Report. and 2002 Annual Report; 401 KAR 65:010. Vehicle emission control programs (Parker Moore, Kentucky Division for Air Quality, personal communication).

Figure 11 Failure Rates in Kentucky for Diesel Vehicle Opacity Test



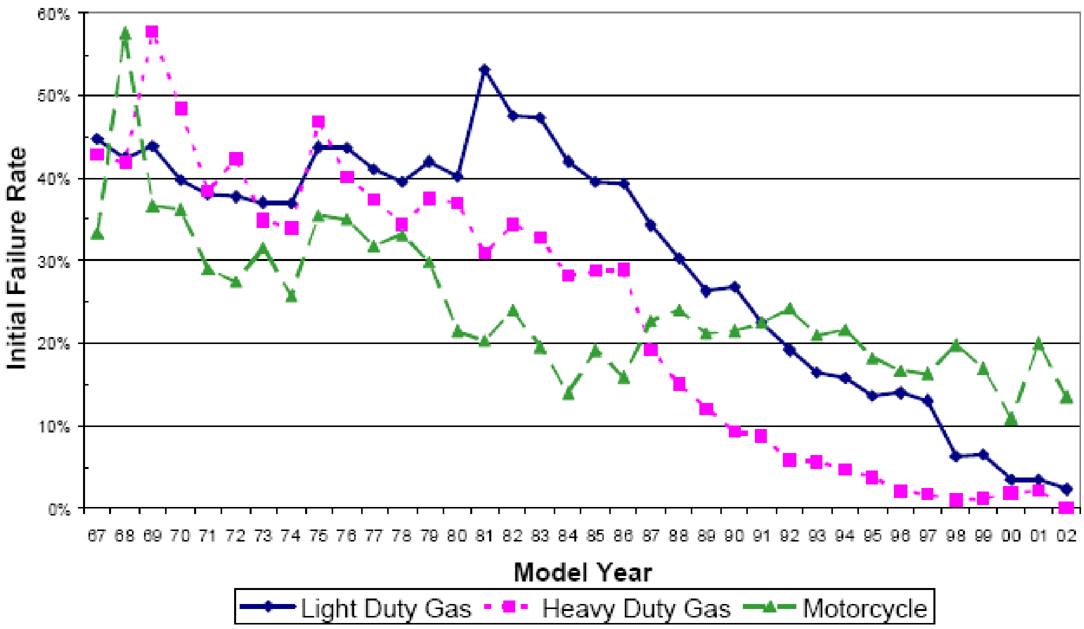
Source: Kentucky Division for Air Quality (2004) Northern Kentucky Emissions Check 2003 Annual Report. and 2002 Annual Report

Figure 12 Failure Rate by Model Year (California 2002)—Petrol Vehicles[1]



Source: Air Resources Board and Department of Consumer Affairs/Bureau of Automotive Repair (2004) Evaluation of the California Enhanced Vehicle Inspection and Maintenance (Smog Check) Program. Draft Report to the Inspection and Maintenance Review Committee
www.imreview.ca.gov/reports/final_draft_eval_report_2004.pdf
[1] Diesel vehicles are exempt from the California programme

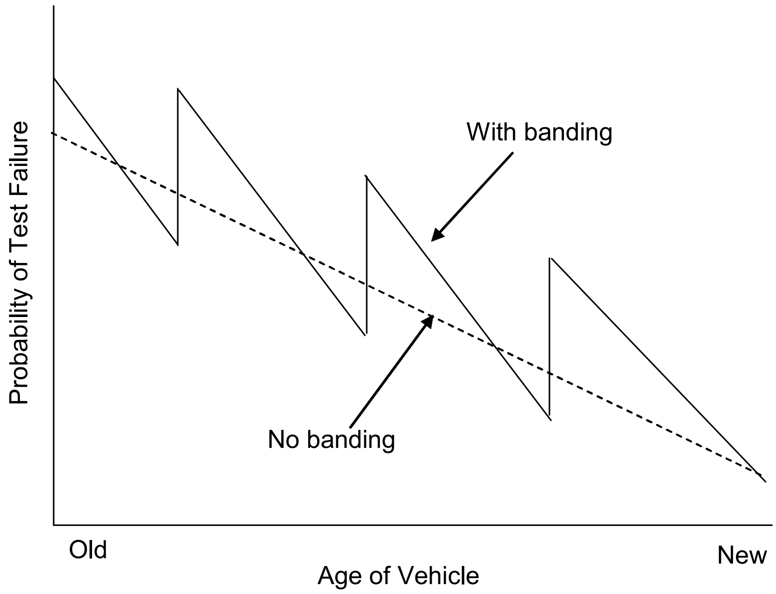
Figure 13 Vehicle Emission Failure Rates by Vehicle Category and Model Year (Arizona 2003)—Petrol Vehicles



Source: Arizona Department of Environmental Quality (2004) Report on Potential Exemptions from Vehicle Emissions Testing for Motorcycles, Collectible Vehicles and Vehicles 25 Model Years Old and Older Prepared to meet the requirements of House Bill 2501 (2002) and House Bill 2294 (2003)
www.azdeq.gov/environ/air/vei/download/HB2501final.pdf

Figure 12 illustrates the likely effect of banded and non-banded performance limits. In the absence of banding, i.e. a single emissions standard that applies to all vehicles, the probability of test failure is much greater for older vehicles. Banding might be introduced with a separate category for each model year. At its extreme it could be used to make the probability of test failure the same in every year. Alternatively, vehicles could be categorised into broad bands with several model years in each band. Here the effect on probability of failure is more likely to be characterised by the sawtooth line in Figure 14.

Figure 14 Impact of Banding on Probability of Test Failure



In some programmes – such as that run by the Greater Vancouver Regional Council, the emissions criteria are set by, year, by fuel, and by engine size—this results in a matrix of test criteria that runs to several hundred values.

3.1.2. Network Requirements

There are three broad approaches that might be required for testing centres:

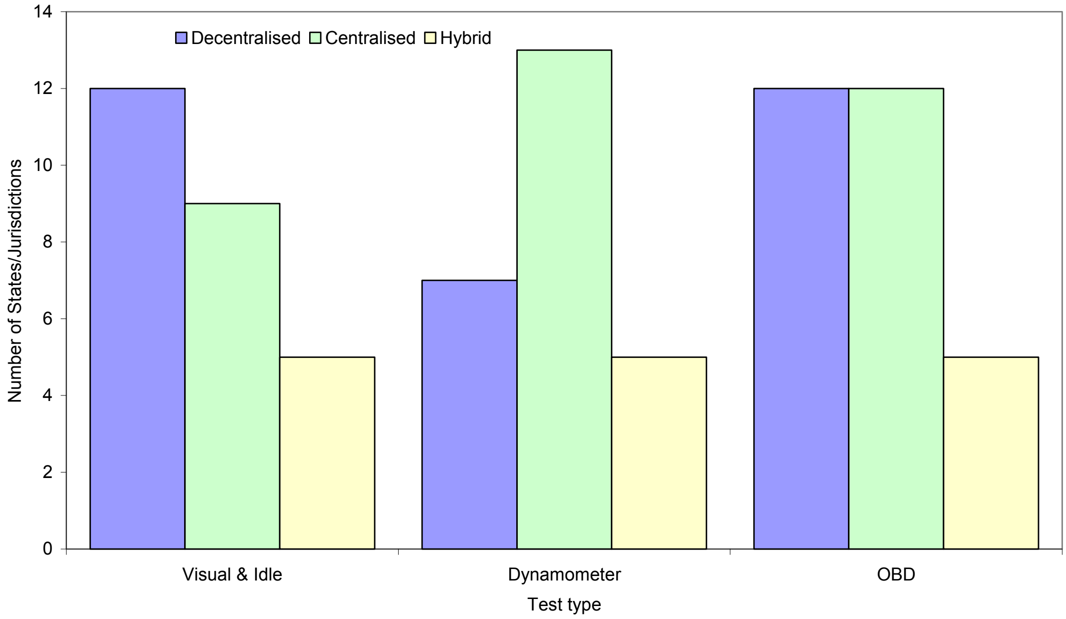
- Centralised—a small number of test-only stations;
- Decentralised—a larger number of (local) garages that both undertake tests and undertake repairs;
- Hybrid—a mix of the two.

The choice depends on a number of considerations. The centralised system might allow use of more complex testing approaches with a higher level of accuracy. This was the assumption in the development of the US programmes where greater credit was given to States that used centralised systems over decentralised[15].

[15] States that are non-compliant with ambient emission standards must adopt State Implementation Programs (SIPs) to achieve these. Emission reduction programmes are assigned credits towards achievement of required emission reductions.

In general, the decentralised network is operated where there is a simpler test type—visual or idle—while those involving dynamometers generally employ centralised facilities (Figure 15).

Figure 15 Relationship between Test Type and Network Type



From the motorist's perspective, centralised systems might be less convenient as there will be fewer of them and it may involve further travel. However, centralised systems would enable economies of scale to be realised with potential reductions in test costs. Table 6 in Section 3.2.1 below confirms this; an analysis of US test fees shows that centralised systems have lower fees on average.

There are potential problems from the separation of the repairs and the test stations in centralised systems. There is a risk that, where garages that repair the vehicles do to have the appropriate test equipment, the vehicles will not be adequately repaired and the vehicle will fail again when it is retested. This "ping-pong" effect has been noted from some US programmes.

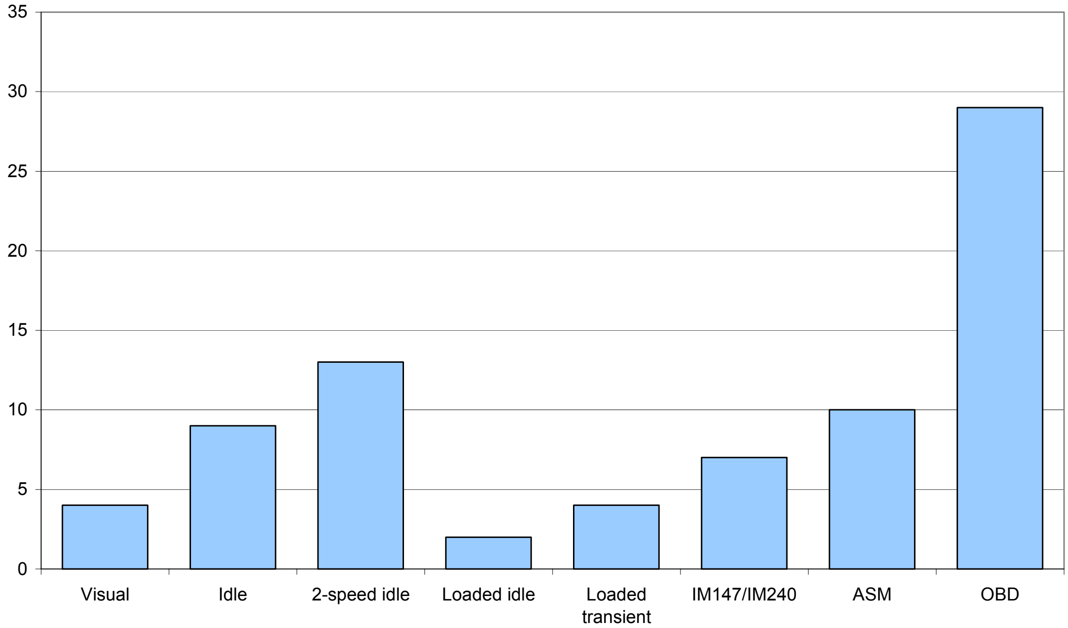
3.1.3. Test Type

There is a wide range of different types of potential test (see Annex 1). The MoT has indicated that it intends to use a relatively simple test regime. The type of test adopted has implications for:

- the costs of the test (see Section 3.2.1) ; and
- its reliability and therefore the number of false positives and other incorrect results.

Figure 16 sets out the different types of test used in jurisdictions in the US. This is simply an addition of the number of States that use each of the different test types.

Figure 16 Use of Different Test Types in the US



Equipment and Tool Institute (2004) I & M Overview. Inspection/Maintenance Program Details by State Updated July 1, 2004 (available at www.etools.org); State program websites. Covec analysis.

A number of States have introduced remote sensing approaches as part of the programme. For example, in Colorado there is a system in which cars can be checked using a rapid drive-by system (RapidScreen) as an alternative to standard emissions testing[16]. The emissions limits for RapidScreen are stricter than those of a standard tailpipe emissions test. If a vehicle records two clean RapidScreen readings within a ten-month period in the year prior to its registration renewal date, the owner will receive a notification in the mail and can simply pay a fee rather than needing to visit a test station. Those that fail the RapidScreen might still pass the regular test.

Remote sensing remains a low cost option to the traditional inspection and maintenance programmes.

A review of the relationship between the results of tests in Australia (Table 5) found that, in general, loaded dynamometer tests had a better correlation with the results of a detailed Federal Test Procedure test (see Annex 1 for explanation of test types). This kind of analysis suggests a potentially greater risk of mis-diagnoses under the simple test procedure. The risks fall in two directions:

- false passes, where high emitters are allowed to pass—the environment suffers from higher emissions;
- false fails, where low emitters fail—households face costs that they should not.

Our concern in this analysis is with the level of false fails and whether these are randomly distributed across the vehicle fleet or concentrated amongst higher than

[16] http://www.aircarecolorado.com/rapidscreen/about.html

average emitters. It is expected that the pilot testing programme will provide some additional information relevant to this.

Table 5 Correlation Between Short and ADR Test Results

	Model year 1974-1986 (ADR27)			Model year 1986 and newer (ADR37/00)		
	HC	CO	NOx	HC	CO	NOx
IM240	0.80	0.93	0.91	0.94	0.90	0.90
ASM	0.52	0.71	0.69	0.64	0.78	0.68
SS60[1]	0.62	0.80	0.74	0.80	0.84	0.72
High Idle	0.49	0.71	N/A	0.70	0.62	N/A
Idle	0.44	0.55	N/A	0.72	0.67	N/A

[1] Steady State loaded 60km/h (dynamometer test)

Source: Federal Office of Road Safety (1996) Motor Vehicle Pollution in Australia. Report on the National In-Service Vehicle Emissions Study

Results from remote sensing programmes have shown linear relationships with high correlation coefficients to the results from IM240 or ASM testing[17], although criticisms of remote sensing include the assumption that a one second snapshot of the vehicle's emissions is characteristic of that vehicle's emission profile[18]. The correlation between results of remote sensing and the more complex loaded dynamometer tests may well be better than that of simple idle tests with the loaded tests.

3.1.4. Vehicle Coverage

The coverage of the test regime by vehicle type is set out in the discussion document. Other regimes have also excluded vehicles depending on age, either for very new vehicles (assumed to be performing well) or very old vehicles (for reasons of economic hardship or because there are very few in the fleet and the implications were not felt to be that great).

Figure 17 shows the earliest model years included in US State programmes. With the exception of Colorado, all States exclude old vehicles from the test regime.

In Canada, the British Columbia scheme includes all vehicles, while the Ontario scheme restricts the requirements to vehicles up to 20 years old.

3.1.5. Frequency

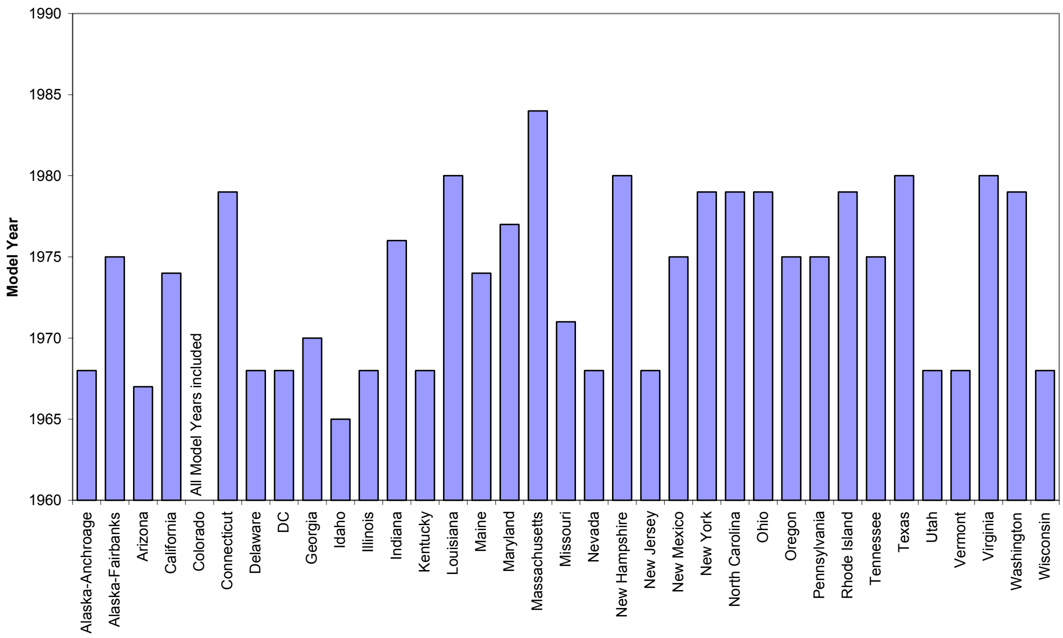
The frequency of emissions screening will affect the probability of costs at any point in time, including the costs of testing and the probability of facing a repair bill. The frequency is also likely to affect the frequency with which motorists service their vehicles.

[17] US EPA (2004) Guidance on Use of Remote Sensing for Evaluation of I/M Program Performance. EPA420-B-04-010. (www.epa.gov/otaq/regs/im/obd/420b04010.pdf)

[18] US EPA (op cit)

In the US, biennial (every two years) test frequency is more common than annual requirements. Some states have a mixture of the two. In Phoenix Arizona, Colorado and Utah, there is a biennial requirement for newer vehicles[19] and an annual requirement for older vehicles[20].

Figure 17 Earliest Model Year Included in the Inspection/Maintenance Programme



Source: Equipment and Tool Institute (2004) I & M Overview. Inspection/Maintenance Program Details by State Updated July 1, 2004 (available at www.etools.org); State program websites. Covec analysis.

3.2. Test Costs

It is expected that the pilot programme will provide estimates of testing costs for New Zealand. In this section we summarise test costs in other countries and use these to estimate likely costs in New Zealand. We use test fees and costs synonymously here; US studies have found bottom-up estimates to be "in the ballpark" of actual fees[21].

3.2.1. Test Fees in Other Countries

Figure 18 shows the current test fees charged in the US by State and by type of test; it includes the equivalent New Zealand dollar amount converted simply using exchange rates. There are a number of points that need to be made in interpreting these data.

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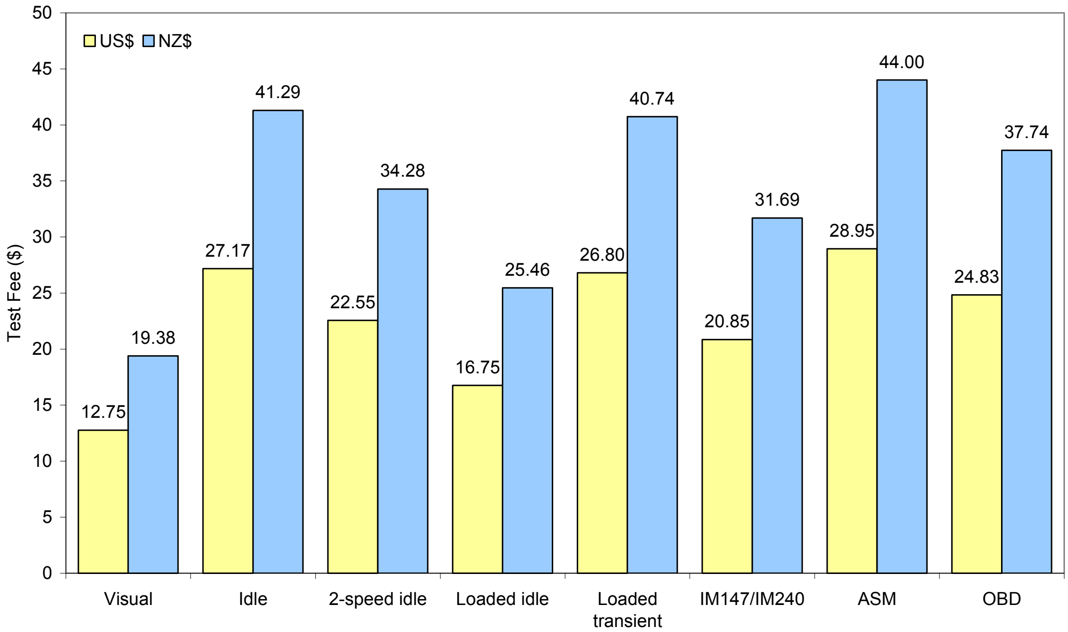
[19] 1981 model year and newer for Phoenix, 1982 and newer for Colorado and 1998 and newer for Utah

[20] Equipment and Tool Institute (2004) I & M Overview. Inspection/Maintenance Program Details by State Updated July 1, 2004 (available at www.etools.org)

[21] Harrington W, McConnell V and Ando (1999) The Enhanced I/M Program in Arizona: Costs, Effectiveness, and a Comparison with Pre-regulatory Estimates. Resources for the Future Discussion Paper 99-37.

- Many States will use different tests depending on the age of the vehicle but charge the same amount; thus these figures are likely to represent the average costs of tests in the states that employ that test type.
- For many States, the test fee also includes a contribution towards State administration costs.
- Nearly all States have OBD tests for vehicles of model year 1996 or newer, so the average for the OBD test (US$24.83) is close to the average fee for all States (US$23.33). Some States (Delaware, DC, Illinois, Indiana and Wisconsin) do not charge a fee; rather the costs are recovered via tax. These have not been included in the averages[22].

Figure 18 Test Fees Charged in the US in $US and $NZ[1]



Source: Equipment and Tool Institute (2004) I & M Overview. Inspection/Maintenance Program Details by State Updated July 1, 2004 (available at www.etools.org); State program websites
[1] US$ converted to NZ$ at US$1:NZ$1.52 = average exchange rate for 2004 (www.oanda.com)

The test costs differ depending on the type of network. Test costs are higher on average in States that operate decentralised testing systems than in centralised, despite the fact that centralised systems tend to employ more expensive (dynamometer-based) tests (Figure 15). The analysis suggests that the cost reductions are because of economies of scale and that these economies are significant.

[22] Wisconsin charges a $15 fee only after the second re-test; we have included this fee in the averages.

Table 6 Test Fees for Different Network Types

	US$	NZ$
All networks	23.3	35.46
Decentralised	25.5	38.70
Centralised	17.8	26.98
Hybrid	26.3	39.98

Source: Equipment and Tool Institute (2004) I & M Overview. Inspection/Maintenance Program Details by State Updated July 1, 2004; Covec analysis

Table 7 shows the number of vehicles tested per station under the different systems in the US. For centralised systems, both the number of facilities and number of lanes per facility are given (where each lane has its own test equipment). On average, decentralised systems have less than 2,500 vehicles tested per annum. In contrast, each centralised facility will have close to 70,000 vehicles tested per annum on average and more than 8,000 per lane at the facility. This means that the test equipment has a greater than three times throughput in a centralised facility.

Table 7 Number of Vehicles per Facility

	No of vehicles per facility
Decentralised Bays	2,452
Centralised lanes	8,407
Centralised facilities	69,697

Source: Equipment and Tool Institute (2004) I & M Overview. Inspection/Maintenance Program Details by State Updated July 1, 2004; Covec analysis

Test fees in Canada are shown in Table 8.

Table 8 Test Fees - Canada

Province	Network	Test type	Fee (C$)	Fee (NZ$)[1]
British Columbia	Centralised	Idle	23	27
		ASM	23	27
		IM240	47	55
Ontario	Decentralised	ASM or 2-speed idle	$15-17.50	17-20

[1] Converted at C$1:NZ$1.16 = average for 2004 (www.oanda.com)
Source: http://www.aircare.ca/ and Equipment and Tool Institute (2004) I & M Overview. Inspection/Maintenance Program Details by State Updated July 1, 2004; Covec analysis

In the UK, the emission inspection cost is part of the MOT inspection (the WOF equivalent); test costs for a passenger car are currently £42.10[23]. The cost of the emission inspection itself is estimated at £7.30[24] in 2001 prices (or NZ$26.70 in current dollars[25]).

[23] www.vosa.gov.uk
[24] AEA Technology (2001) An In-Service Emissions Test for Spark Ignition (SI) Petrol Engines—PPAD 9/107/09. Phase I Report Definition of an excess emitter and effectiveness of current annual test. A report produced for the DTLR VSE Division. Appendix 5 Details of the cost effectiveness calculations
[25] Converted to NZ$ at £1:NZ$3.43 = average for 2001 (www.oanda.com), then inflated to 2004 prices using Reserve Bank CPI Inflation Calculator (www.rbnz.govt.nz/statistics/0135595.html)

An analysis of the costs of inspection in the Netherlands[26], when it was operating under EC legislation requiring an idle test, was 10ECUs[27] (NZ$25 in 2004 dollars[28]).

3.2.2. Estimate for New Zealand

The range of test cost for the facilities using tests most similar to the proposed NZ scheme are shown in Table 9.

Table 9 Summary of Test Fees in NZ$

Jurisdiction	Test fees (NZ$)
US (Idle and 2-speed idle)	34-41
Canada	17-27
UK	27
Netherlands	25

We assume that the test costs will be lower in New Zealand because of lower wage rates, and in the range of NZ$20-30/test. This is a significant cost when aggregated across all vehicle owners, but is small in comparison with the size of possible repair costs falling on individual motorists whose vehicle fails the test.

3.3. Repair and Maintenance Costs

As a result of the emissions screening programme, there will be some vehicles that fail the test. They will face the decision of whether to repair the vehicle or not. In this section we explore the likely costs of repairs. Alternatively, vehicle owners may choose to tune their vehicles more regularly in order to avoid the need for remedial repairs.

3.3.1. Repair Costs

Repair Costs are expected to be estimated during the pilot programme. In the absence of these data, we use information from overseas test programmes to estimate likely costs.

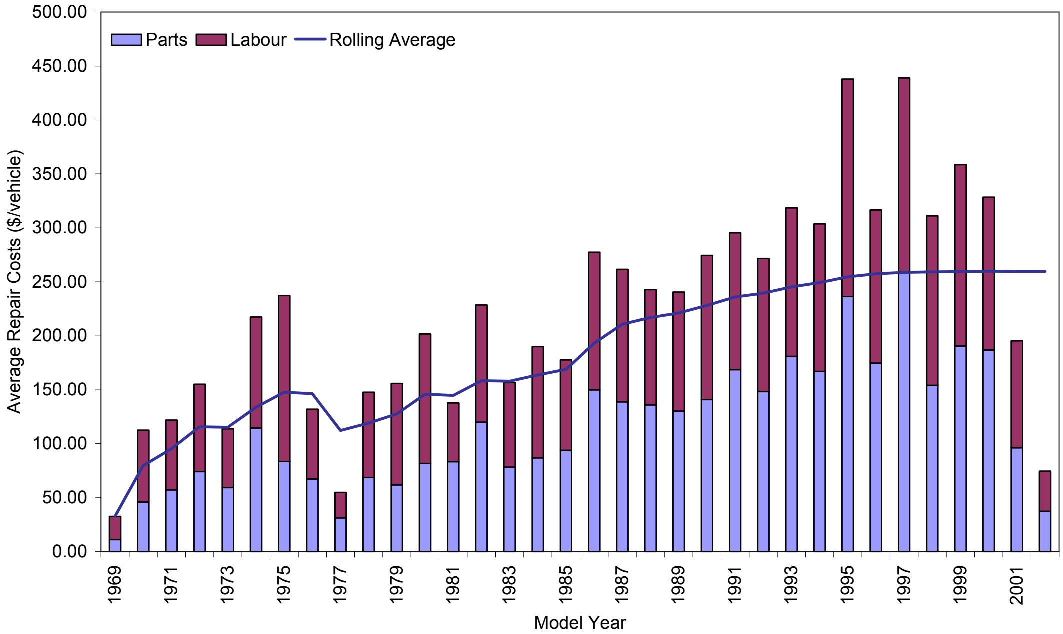
Figure 19 reports estimated repair costs associated with the Northern Kentucky programme; costs average US$260. This includes all vehicles—petrol- and diesel-powered, although there are much larger numbers of petrol-powered vehicles in the sample. The figure also includes a rolling average, estimated as the average repair cost as we move from left to right in the figure including more model years. The overall average repair cost increases as newer vehicles are included in the analysis.

[26] LAT, Aristotle University of Thessaloniki, INRETS, TNO, TUV Rheinland and TRL (1998) The Inspection of In-Use Cars in Order to Attain Minimum Emissions of Pollutants and Optimum Energy Efficiency. Main Report. European Commission

[27] European Currency Units—the forerunner to the Euro

[28] Converted from ECUs to NZ$ at ECU1:NZ$2.24 (rate for 1998) and inflated to 2004 values using Reserve Bank CPI inflator

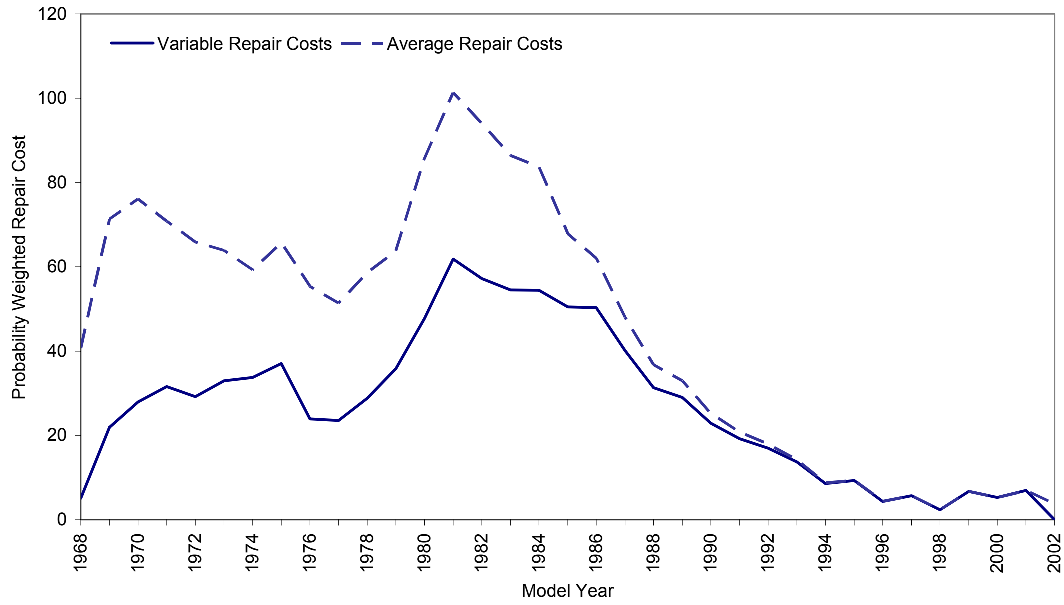
Figure 19 Average Repair Costs by Model Year for the Kentucky Programme (average over 2002 & 2003)



Source: Kentucky Division for Air Quality (2004) Northern Kentucky Emissions Check 2003 Annual Report and Kentucky Division for Air Quality (2003) Northern Kentucky Emissions Check 2002 Annual Report.

From these data we can construct a probability weighted repair bill with age; this is estimated by multiplying the probability of failure (= the percentage of vehicles that fail in each age class—see Figure 10) with the expected repair bill. The results are shown in Figure 20. Two curves are shown; one is based on the variable repair costs, ie the average repair costs for each model year; the other uses a single average repair cost for each model year, if we assume that repair costs do not vary with vehicle age. The trend is of an increasing risk through to the 1981 model year, from which time the repair cost risk falls steadily to low levels for new vehicles. The peak corresponds to the time when the cut-points fall to their most stringent level (Figure 10), ie it is where the oldest cars have to meet the most stringent cut-point. If we assume that the Kentucky trends are correct, ie that repair costs are lower for older cars, then the solid line is the better fit; it results in a lower probability-weighted repair cost in all year—early years when the probability of failure is high, has low repair costs but later years that have higher repair costs have lower probabilities of failure. Usefully these relationships could be examined for New Zealand.

Figure 20 Probability Weighted Repair Costs



Estimates of average repair costs in other jurisdictions are shown in Table 10.

Table 10 Estimates of Average Repair Costs

	Average Repair Cost	NZ$ equivalent[7]
California	US$154[1]	$234
Oregon – 2 speed idle	US$75[2]	$114
Oregon – dynamometer	US$180[2]	$274
Texas	US$500[3]	$760
British Columbia	C$367[4]	$426
UK	£195[5]	$540
EU – Minor repair	90 ECU[6]	$226
EU – Major repair	190 ECU[6]	$477
EU – replacement of catalyst	500 ECU[6]	$1256

[1] California Dept. Consumer Affairs -- Bureau of Automotive Repair (2003) Executive Summary Report Smog Check Calendar Year:2003;

[2] Oregon Department of Environmental Quality estimates repair costs differ depending on test type - www.deq.state.or.us/aq/vip/ifyoufail.htm

[3] This is the average cost for repairs for vehicles under the State assistance programme for low income households—AirCheck Texas (2004) AirCheck Texas Repair and Replacement Assistance Program. Presentation to Surface Transportation Technical Committee September 24, 2004. (www.nctcog.org)

[5] AEA Technology (2001) An In-Service Emissions Test for Spark Ignition (SI) Petrol Engines—PPAD 9/107/09. Phase I Report Definition of an excess emitter and effectiveness of current annual test. A report produced for the DTLR VSE Division. Appendix 5 Details of the cost effectiveness calculations.

[6] LAT, Aristotle University of Thessaloniki, INRETS, TNO, TUV Rheinland and TRL (1998) The Inspection of In-Use Cars in Order to Attain Minimum Emissions of Pollutants and Optimum Energy Efficiency. Main Report. European Commission

[7] Converted at average 2004 exchange rates (www.oanda.com): US$1:NZ$1.54; C$1:NZ$1.16; £1:NZ$2.77 The UK data are from 2001 but later reports in the UK have used this same figure; we assume no change in nominal terms. 1 ECU:NZ$2.242 (1998 exchange rate) – as these are 1998 data, they are inflated to 2004 NZ$ values using Reserve Bank CPI inflation calculator

Our interest in analysis is with the range in repair costs, not just the average. To understand the social impacts, it is useful to understand the effects of the range of possible outcomes. The data on repair costs include a mixture of petrol-only and petrol and diesel fleets, however petrol vehicles are more highly represented largely because many of the programmes focus on CO, HC and NOx emissions for which diesel vehicles have much lower emission rates on average.

The analysis above suggests that repair costs can differ widely; quoted averages range from NZ$114-1256. In addition, waiver programmes have been introduced in order to limit costs for customers with; the maximum repair threshold (in Colorado) is set at US$715 ($1087) (see Section 6.1 below). At a lower threshold of $450, approximately 1,000 vehicles per year were claiming assistance. We can assume that repair costs in the order of NZ$1,000 would be at the high end of likely costs.

Repair costs may not be a one-off cost. A review of the Arizona IM240 programme found[29] that 40% of vehicles that failed their initial test in 1995 failed again in 1997. About half of these failed for the same combination of pollutants in both years. And remote sensing data indicate that repair effectiveness drops as soon as a few months after a vehicle's final I/M test.

3.3.2. Maintenance

In addition to the costs of repair, many vehicles will have increased costs for preventive measures, eg more frequent servicing to ensure that they meet the test requirements.

At this stage we are unclear as to the proportion of emission failures that would be addressed by tuning. It is expected that results from the pilot programme will contribute to this.

Some analyses have addressed the emission benefits of tuning. An Australian analysis demonstrated that tuning resulted in a reduction in average emissions (Table 11); however, the results need to be interpreted carefully as the effect was not uniform across all vehicles. Rather, the principal effect was on the worst performers in the fleet.

Table 11 Average Reduction in Emissions as a Result of Tuning

Emissions	All Cars	Model Year 1974-1986 (ADR 27)	Model Year 1986+ (ADR 37/00)
HC	16%	14%	21%
CO	25%	26%	24%
NOx	9%	8%	9%

Source: Federal Office of Road Safety (1996) Motor Vehicle Pollution in Australia. Report on the National In-Service Vehicle Emissions Study

This result was also found in European tests; maintenance has a small impact on the average vehicle while having a more significant impact on the worst emitters[30].

[29]Lawrence Berkeley National Laboratory (http://enduse.lbl.gov/Projects/vehicles/Evaluation.html)
[30] LAT, Aristotle University of Thessaloniki, INRETS, TNO, TUV Rheinland and TRL (1998) The Inspection of In-Use Cars in Order to Attain Minimum Emissions of Pollutants and Optimum Energy Efficiency. Main Report. European Commission.

Servicing regularly rather than in response to a failure will provide some greater certainty of passing the test but also greater certainty of costs. There will be some compensating benefits from fuel economy (see below).

3.4. Compensating Improvements in Fuel Consumption

There is a relationship between emission rates and fuel consumption, and vehicles that are tuned to correct pollution rates can see an improvement in fuel efficiency.

In Australia, a 1.5% improvement in fuel efficiency was achieved for vehicle tuning. However, for the highest 10% of emitters, tuning led to an average fuel consumption gain of over 5%[31].

The fuel consumption benefits have been estimated for the British Columbia system. Data were compiled for 695 vehicles that failed their initial inspection and passed their second inspection. The average fuel consumption (liters/100 km) and average emissions of CO_2 per kilometre were calculated before and after repairs. In the case of CO_2, 1.57 times the CO emissions per km were added to the CO_2/km. This was done to reflect the oxidation of CO to CO_2 in the atmosphere. Results of this analysis are presented in Table 12.

The British Columbia programme appears to result in greater reductions in greenhouse gases and fuel consumption for newer models than older models based on the sample data set. Weighted average fleet impacts on fuel consumption are small. European studies show that there is a negligible effect of vehicle maintenance on fuel economy/CO_2 emissions[32].

Table 12 Impact of British Columbia Programme on Fuel Consumption and CO_2 Emissions

Parameter	1981	1982-87	1988-91	1992-95	1996+	Weighted average
% reduction in L/100km	1.32%	-0.87%	-0.48%	1.02%	5.03%	0.36%
% reduction in CO_2	0.20%	-2.25%	-1.11%	0.70%	4.76%	-0.42%

Source: Levelton Consultants ltd, de la Torre Klausmeier Consulting Inc and Eastern Research Group (2004) Aircare Program Technical Review Phase 1

The analysis suggests that there will be some emission fuel economy improvements for vehicles for which tuning is required to meet the emission limit.

3.5. Loss of a Vehicle

The loss of a vehicle occurs:

[31] Federal Office of Road Safety (1996) Motor Vehicle Pollution in Australia. Report on the National In-Service Vehicle Emissions Study.

[32] LAT, Aristotle University of Thessaloniki, INRETS, TNO, TUV Rheinland and TRL (1998) The Inspection of In-Use Cars in Order to Attain Minimum Emissions of Pollutants and Optimum Energy Efficiency. Main Report. European Commission

- in the short run, when a household is waiting for the vehicle to be repaired or to purchase a replacement vehicle; or
- in the long run, because the costs of repair or to purchase a replacement vehicle are too high.

The decision to scrap a vehicle occurs where the costs of doing so, including the purchase of a replacement, or living without the vehicle, are less than the ongoing costs of running the existing vehicle. This includes the decision for households for which repairing and continuing to use the existing vehicle involves additional household debt.

Because of the relationship between emissions, the risk of failing a test and vehicle age, it is likely that more vehicles will be scrapped earlier as a result of the screening programme, and that more households will choose to live without a vehicle.

3.6. Incentives for Un-Warranted Vehicles

In addition to households choosing not to operate a vehicle, one of the incentives that the emission screening programme may provide is for driving vehicles unwarranted. Already there is a significant number of vehicles that are unregistered or un-warranted Of the 42,000 vehicles sampled in the NIWA remote sensing study for the ARC[33], 590 (1.4%) had no current WoF, and 120 (0.3%) had not had a WoF for 6 months or more. If this holds nationally, there may be 8,500 vehicles on the road that have not undergone a WoF inspection for extended periods.

The introduction of the emissions screening programme will add to these incentives. This has potential consequences for vehicle safety as well as emissions.

Overseas experience confirms this. A review of the Arizona IM240 programme found[34] that one-third of all vehicles that fail initial I/M testing never receive a passing test; about one-third of these vehicles are observed by remote sensors still being driven in the I/M area more than 2 years after their last (failing) I/M test. In addition, 40% of all vehicles tested in the first year of Enhanced program in Arizona (1995) were not tested in the next cycle (1997).

The separation of the emissions inspection from the WOF might limit these effects to some extent, i.e. the emissions requirement would provide no additional incentive to avoid the WOF, apart from its effect on income. However, for this to hold, it would be necessary that the emissions inspection requirement did not lead to withholding of registration—most likely to be part of the penalty for non-compliance. If failing the emission test led to loss of registration, the incentive for having a WoF is reduced also.

Thus, for households that are vehicle dependent and cannot readily afford the repair or tuning bill, depending on penalties, there may be an increased probability of driving vehicles without a warrant.

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[33] Fisher GW, Bluett J, Xie S and Kuschel GI (2003) On-road remote sensing of automobile emissions in the Auckland region: Analysis and presentation of the full data set. NIWA Report AK2003-93. 84 p.
[34] http://enduse.lbl.gov/Projects/vehicles/Evaluation.html

This has the potential to increase accident rates, with risks both for the driver and other road users.

3.7. Emission Rates, Effects and the Implications for Testing

The analysis in this section has examined the performance of emissions screening programmes in other countries and the pattern of failure rates, particularly against vehicle age. Applying these experiences to New Zealand assumes that the way in which an emissions screening rule is defined will be with respect to emission rates. At this stage the emissions screening rule as not been defined and a number of issues need to be borne in mind, particularly in relating the measurement of emission rates with the objectives of the policy.

The health and environmental impacts of vehicle emissions are associated with ambient concentrations of pollutants and population exposure. The relationship between the exhaust gas concentration and effects depends on a number of factors discussed below.

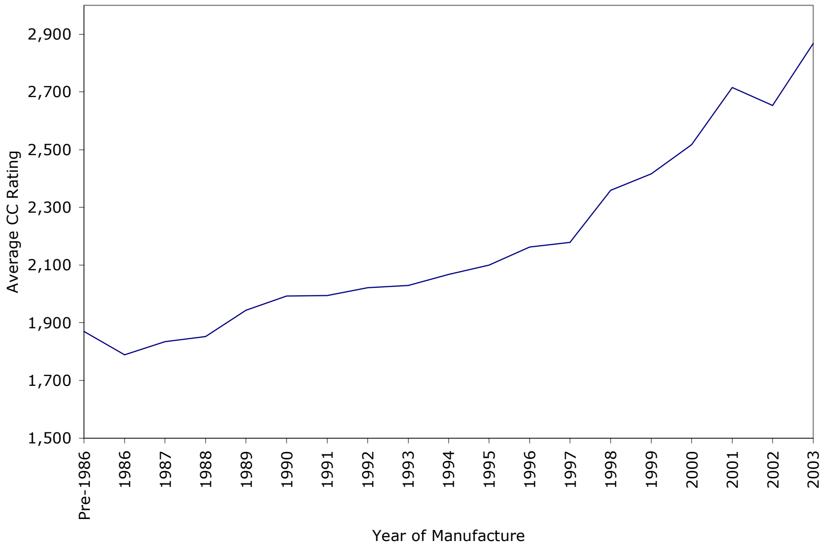
3.7.1. Air Volume

The volume of air in the exhaust gas—small cars may have high concentrations of pollutants because they have small amounts of exhaust gas. In contrast, large vehicles will have large volumes of exhaust gas. However, the ambient concentration will depend on the mass of pollutant rather than the concentration. Simple idle emission tests do not measure emission mass. There are relatively simple methodologies for converting from concentrations to emissions mass (as grams per km, for example[35]) but dynamometer tests provide a better measure of total emissions.

An evaluation of the size of vehicles with model year (Figure 21) shows that vehicles have been increasing in size on average over time. This suggests that, on average, for a given emissions concentration, the total emissions will be expected to be greater for a more recent vehicle.

[35] see Bluett J and Fisher G (2004) What is being discharged from that tailpipe? Modelling versus measurements. Paper to 27th Australasian Transport Research Forum, Adelaide 29 September-1 October 2004.

Figure 21 Average Vehicle Size

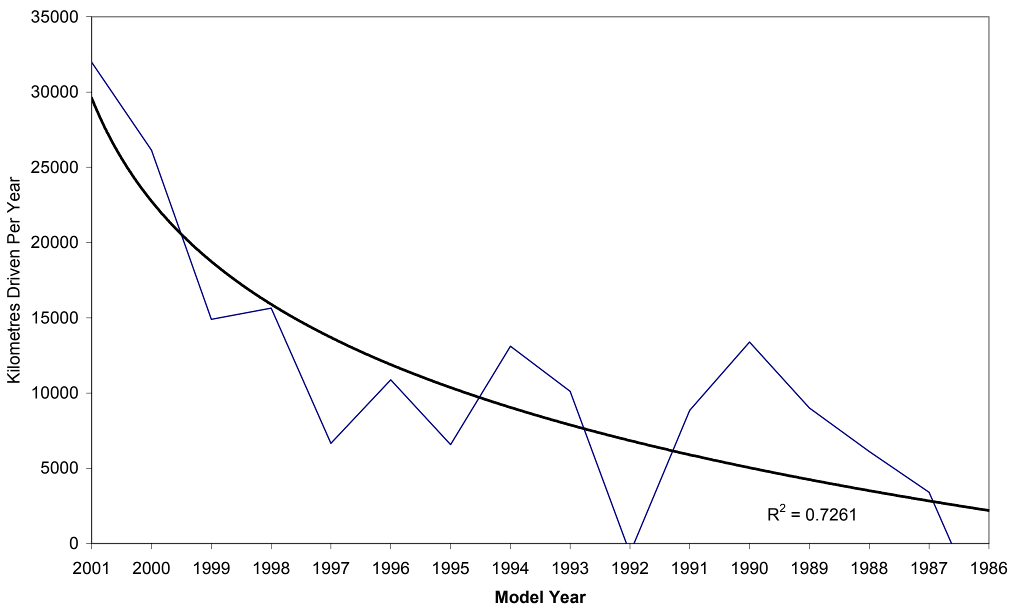


Source: LTNZ; Covec analysis

3.7.2. Vehicle Use

A high-emitting vehicle that is used very little can have less impact on the environment than a low-emitting vehicle that is used a lot. There may be greater benefit from improving the emissions of high use vehicles than low use vehicles. Analysing the kilometres travelled data by year of manufacture suggests that the marginal additional kilometres travelled falls with age, ie as cars get older they are driven less (Figure 22).

Figure 22 Kilometres Driven by Vehicle Age



Source: LTNZ; Covec analysis

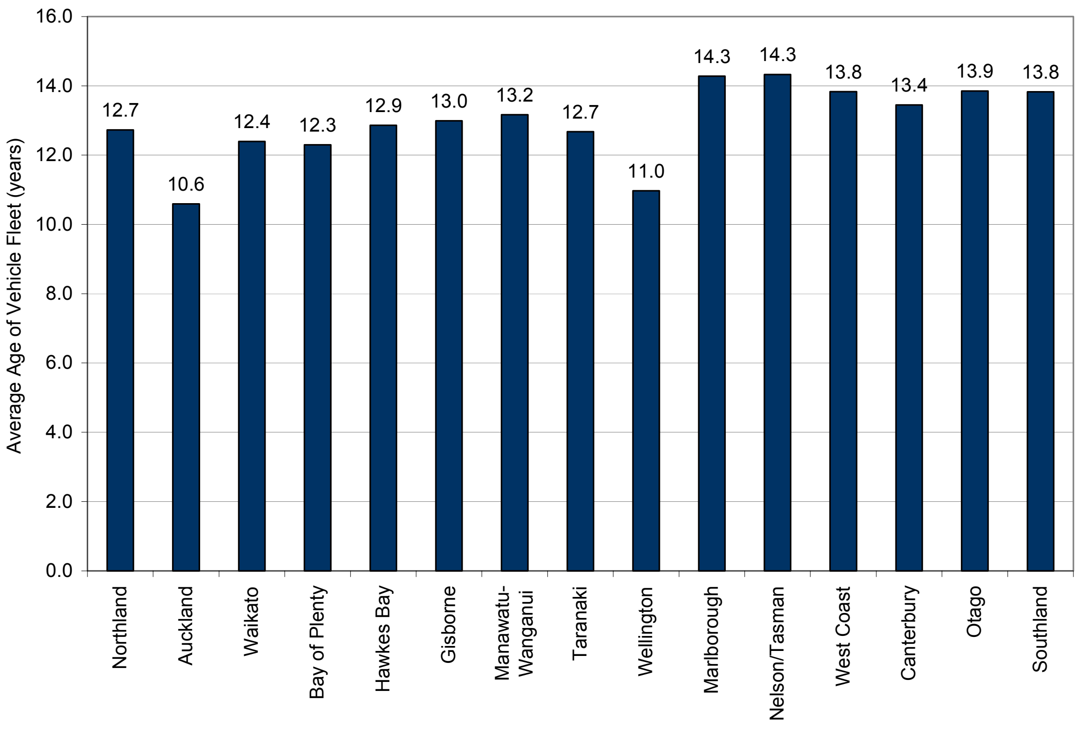
This relationship is produced by taking the difference between the average odometer reading of all vehicles in a given model year, less the average odometer reading of all vehicles in the previous year. This produces a curve for the marginal kilometres travelled with age. This is an additional result that suggests that the relationship between vehicle age and emission impact is much less than implied by simply examining vehicle concentrations.

3.7.3. Location

Emissions will have a greater effect if they occur close to other people. Thus emissions from vehicles that travel through congested corridors can be especially problematic.

This is more difficult to measure from the data as we have little understanding of where vehicles are used. However, we might assume that vehicles are driven close to where they are registered. Figure 23 shows that the average age of the vehicle fleet is lower in the major urban areas—Auckland and Wellington. The implication is that introducing a scheme that is based on concentrations, rather than taking account of impacts, will emphasise older vehicles which might not be those with the greatest impacts.

Figure 23 Average Age of Vehicle Fleet by Region



Source: LTNZ; Covec analysis

3.7.4. Implications for Policy

The analysis of costs and benefits of the testing regime is beyond the scope of this study. However, the simple analysis presented above suggests that the factors that determine impacts have implications for the type of test used and the way in which cutpoints might be established.

In terms of tests, it suggests that loaded tests that measure mass emissions provide a better basis for determining impacts than idle test. However, the results of idle tests might be combined with conversion factors to produce mass emission equivalents.

The use of a vehicle, including levels of use and their location are important factors also. Consideration should be given to whether they can be taken into account in a screening rule or require an alternative policy instrument.

3.8. Conclusions

The broad conclusions that can be drawn from an assessment of the expected emission screening programme are that:

- the failure rate under a simple emissions test is expected to increase with age of vehicle, reflecting the increased emission rates;
- banding can limit this relationship, and this can reduce the effectiveness of an emission screening programme in eliminating the vehicles with the highest emission rates;
- test costs are likely to be in the order of $20-30;
- Repair costs would be expected to vary widely from close to nothing to over $1,000;
- as a result of the required repair costs, some vehicle owners will choose not to repair their vehicle and face either the cost of a replacement or of living without a vehicle;
- there will be increased incentives to operate a vehicle without a warrant.

There are a number of points that are raised relating to the design of the programme itself:

- Centralised networks are likely to show economies of scale with resulting lower average test costs;
- Remote sensing screening programmes may have a role – specially in larger urban centres – for targeting gross emitters (and may also have a co-benefit in identifying unwarranted vehicles)

3.9. Work in Phase II

In Phase II we expect to have a clearer understanding from MoT of the rules for the emissions screening programme, including the way in which cut-points are established and the banding of vehicles.

Output from the pilot programme will be used to supplement the data presented in this section on test and repair costs.

The revised analysis and updated data will provide the basis for the assessment of the initial effects on owners and users of failing vehicles.

The provisional results from this section provide useful inputs to the focus group analysis. Specifically, it establishes a likely range for repair costs and provides initial information on the expected level of test costs.

4. Risks of Test Failure

In this section we combine the NIWA/ARC data, LTNZ vehicle data and census data to associate those vehicles most likely to fail the emissions test with characteristics of the owners. This is a very provisional analysis using these datasets. In Phase II this analysis will be replaced by assessment using the more detailed LTNZ dataset alongside the emissions results of the pilot testing programme.

Our analysis of the vehicles most likely to fail the test is limited in this section to older vehicles. Because of data and time constraints the analysis in this section is limited to petrol-powered passenger vehicles, which make up around 82% of the entire motor-powered vehicle fleet, and 92% of passenger vehicles. Average emissions levels per vehicle for each region have been estimated as follows:

1. the LTSA database is used to estimate the age distribution of vehicles owned by residents of each region;
2. the results from the ARC vehicle testing programme are used to identify the relationship between the age of a vehicle and its emissions characteristics;
3. these two data sources are combined to derive an estimate of the gross emissions levels of vehicles owned by residents in each region;
4. the gross emissions levels in each region is divided by the total number of vehicles to estimate the average emissions levels per vehicle.

This analysis measures emission levels of CO and HC in percentage terms.

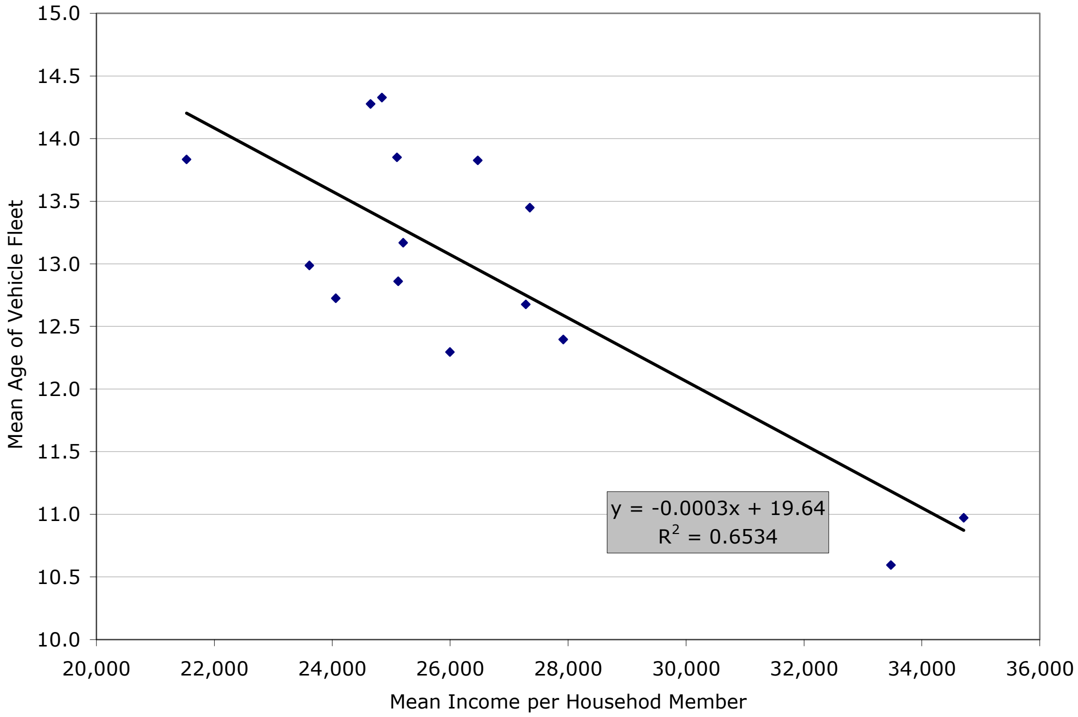
4.1. Relationship between Vehicle Age and Income Level

This relationship has been established by correlating the average vehicle age with average household income at a regional level. Following international best practice, average household income has been calculated as average household income from the census divided by the square root of the average number of occupants per household. This provides a more refined estimate of actual spending power.

The analysis shows that there is a strong negative relationship between average income and the average age of the vehicle fleet at the regional level i.e. people in relatively poorer regions tend to purchase older (cheaper) cars.

This is an obvious finding, but an important one in the sense that it demonstrates that lower income households are more likely to own old cars, and based on the discussion above we expect older cars to have a higher likelihood of failing an emissions test.

Figure 24 Relationship between Average Vehicle Age and Average Income Level



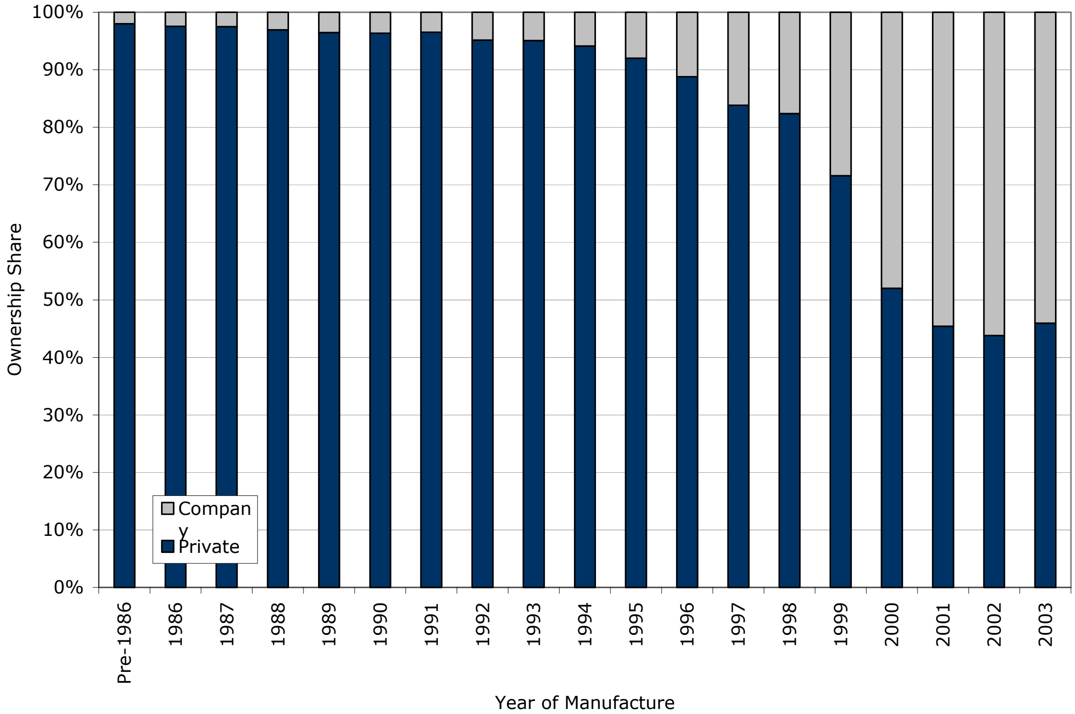
The implied relationship between emissions and income levels is confirmed by overseas studies. In California, a study of the socioeconomic characteristics of high-emitters found that[36]:

- the average income of drivers of high-emitting vehicles was significantly less than that of motorists driving low-emitting vehicle. ($18, 365 vs $36,508);
- 32 percent of the high-emitting vehicle drivers had an annual family income of less than $10,000. Only 13 percent of the low-emitting vehicle drivers had such low family income levels;
- 74 percent of the high-emitting vehicle drivers had a per capita income of less than $10,000. Only 37 percent of the low-emitting drivers had such low per capita income;
- 76 percent of high-emitting vehicle drivers felt that money was the major reason for not tuning up the vehicle.

The LTNZ data indicate that companies own over 50% of cars manufactured in or after 2000, and less than 10% of cars manufactured in or before 1995. Based on the assumption that older cars will have a higher propensity to fail an emissions test the burden of vehicle emissions testing will fall mainly on private households.

[36] Sorbo N and Palen E "City of Los Angeles Remote Sensing Pilot Project" in: Kenneth Green K (1997) CHECKING UP ON SMOG-CHECK: A Critique of Traditional Inspection and Maintenance Programs Policy Study No. 222. Reason Public Policy Institute

Figure 25 Relationship between Age of Vehicle and Owner Type



4.2. Average Fleet Age by Region

The LTNZ data show that the vehicle fleets in Auckland and Wellington are significantly newer on average than those in other New Zealand regions (Figure 23 in Section 3.7.3). This is most likely due to the higher average incomes, and higher proportions of late model business/lease vehicles in these regions.

The North Island regions, excluding Auckland and Wellington, have average fleet ages of between 12.3 years (Waikato) and 13.2 years (Manawatu-Wanganui), while the South Island regions have average fleet ages of between 13.4 years (Canterbury) and 14.3 years (Marlborough and Nelson/Tasman). Hence, the youngest vehicle fleet in the South Island (Canterbury) is still older then the oldest vehicle fleet in the North Island (Manawatu-Wanganui).

The average age of the national fleet was 12.0 years in 2003, while the average for the North Island was 11.5 years and the average age for the South Island was 13.7 years.

4.3. Regional Emissions Rates

Combining the vehicle fleet data with the emissions data allows us to estimate the average emissions per vehicle in each region.

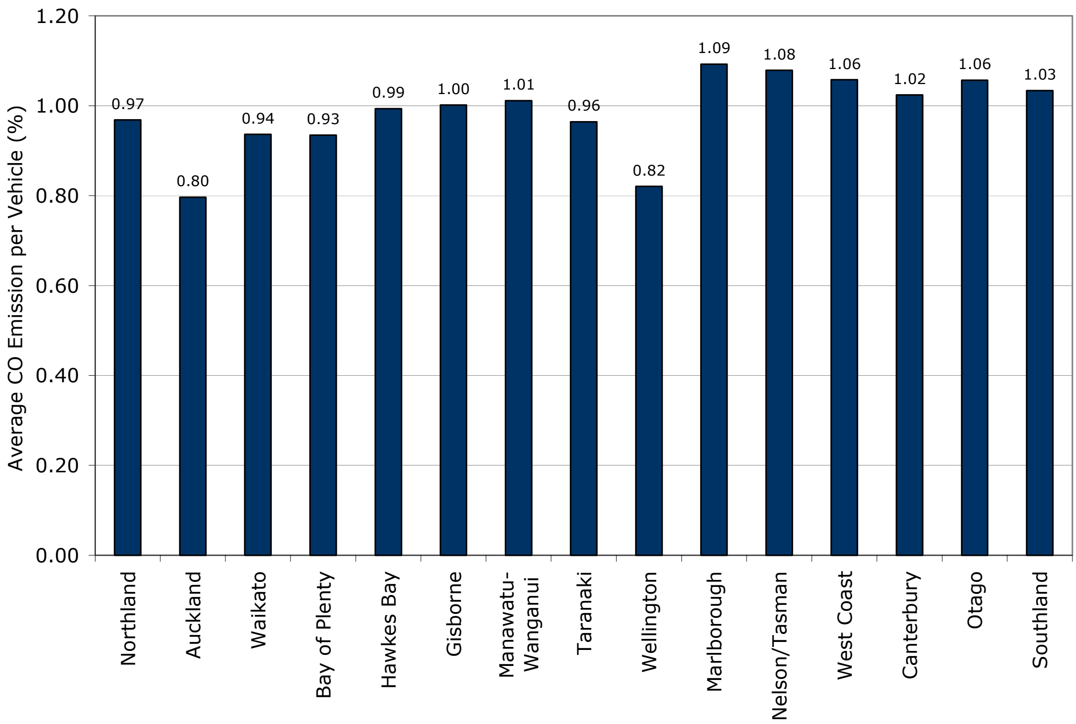
4.3.1. CO Emissions

The data suggests that on average the Auckland and Wellington fleets generate significantly less CO than the other regional fleets. The average CO emission for an Auckland owned vehicle is 0.80%, while the same for Wellington is 0.82%.

Of the remaining North Island regions, Bay of Plenty has the lowest average CO level at 0.93%, while Manawatu-Wanganui has the highest at 1.01%. The average CO levels for the South Island fleets are all in excess of 1.01%, with Canterbury recording the lowest South Island level of 1.02%, and Marlborough recording the highest level of 1.09%.

The average CO emission for the national fleet is 0.91%, while the average for the North Island is 0.87% and the average for the South Island is 1.04%.

Figure 26 Average CO Emissions by Region



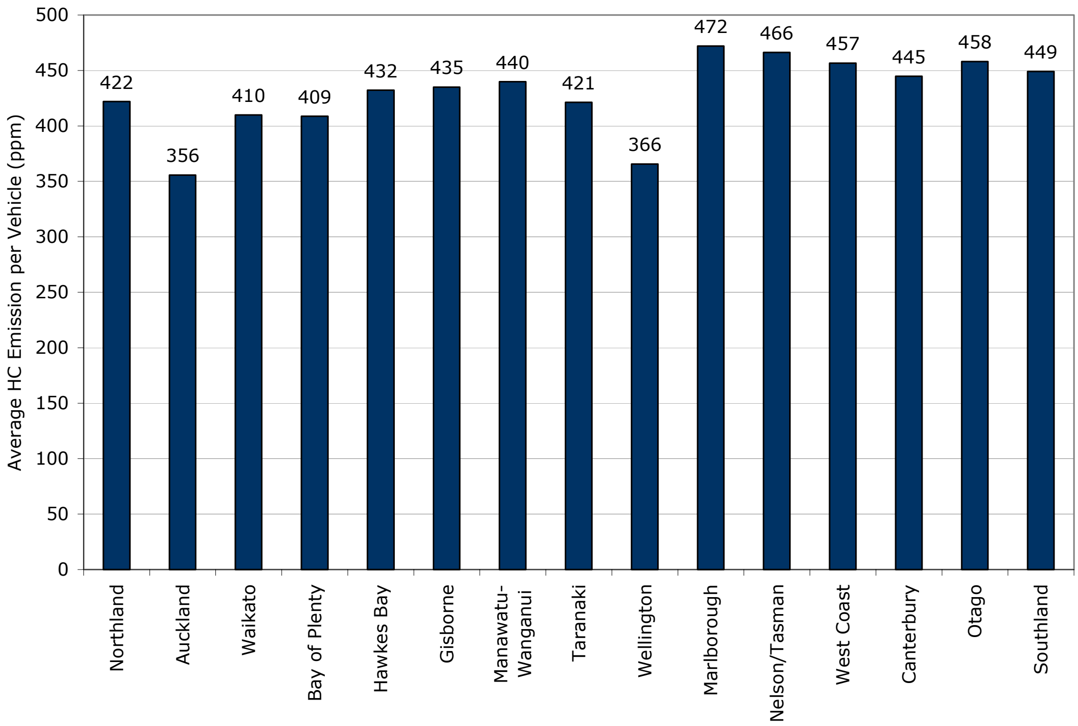
4.3.2. HC Emissions

As with CO, the data suggest that, on average, the Auckland and Wellington fleets generate significantly less HC than the other regional fleets. The average HC emission for an Auckland owned vehicle is 0.036%, while the same for Wellington is 0.037%.

Of the remaining North Island regions, Waikato and Bay of Plenty have the lowest average HC levels at 0.041%, while Gisborne and Manawatu-Wanganui have the highest at 0.044%. The average HC levels for the South Island fleets are all greater than or equal to the North Island levels, with Canterbury on a par with the worst North Island regions at 0.044%, and Marlborough and Nelson/Tasman recording the highest levels of 0.047%.

The average HC emission for the national fleet is 0.040%, while the average for the North Island is 0.038% and the average age for the South Island is 0.045%.

Figure 27 Average HC Emissions by Region

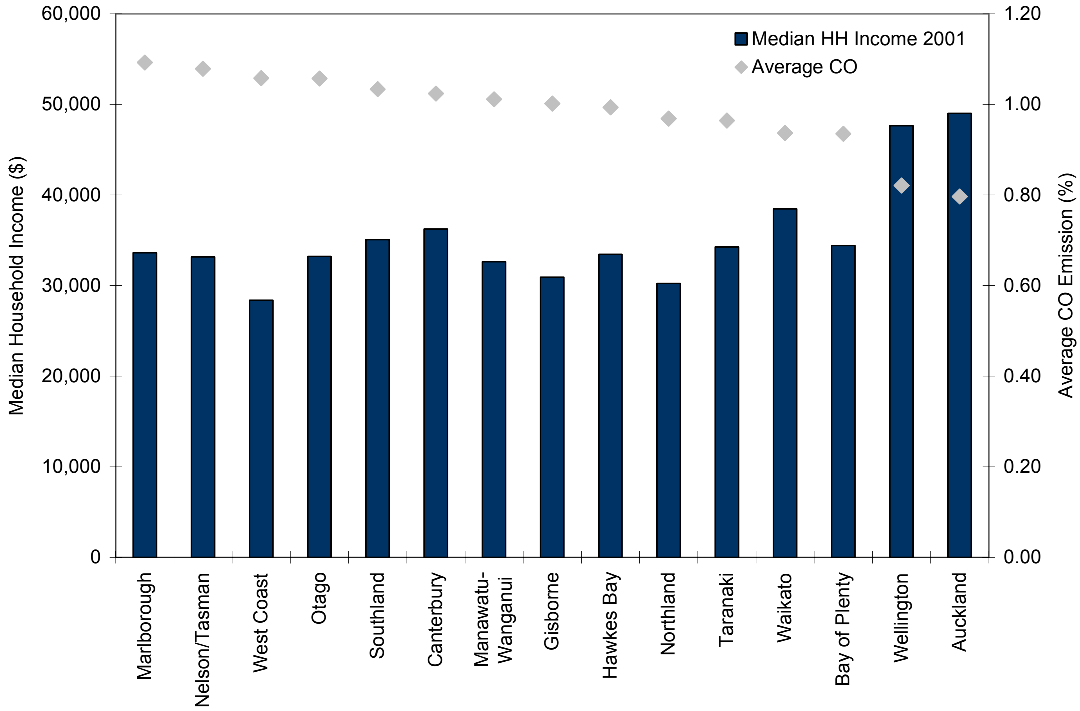


4.4. Regional Income

The data suggest that, on average, those regions with the highest emissions levels have some of the lowest income levels. This implies that in relative terms these regions will not only experience higher failure rates, but they will also, on average, have a lower ability to repair and/or replace their vehicles.

It should be noted that within each of these regions the burden of the emissions testing is unlikely to fall evenly across the population. Given the strong negative correlation between vehicle age and income level it is reasonable to assume that the lowest income earners are likely to own the oldest cars (on average), which puts them at greater risk of failing the emissions test. They are also less likely to be able to afford the cost of repairing or replacing their vehicle(s) because of their low incomes.

Figure 28 Regional Incomes vs. Average CO Emissions Levels

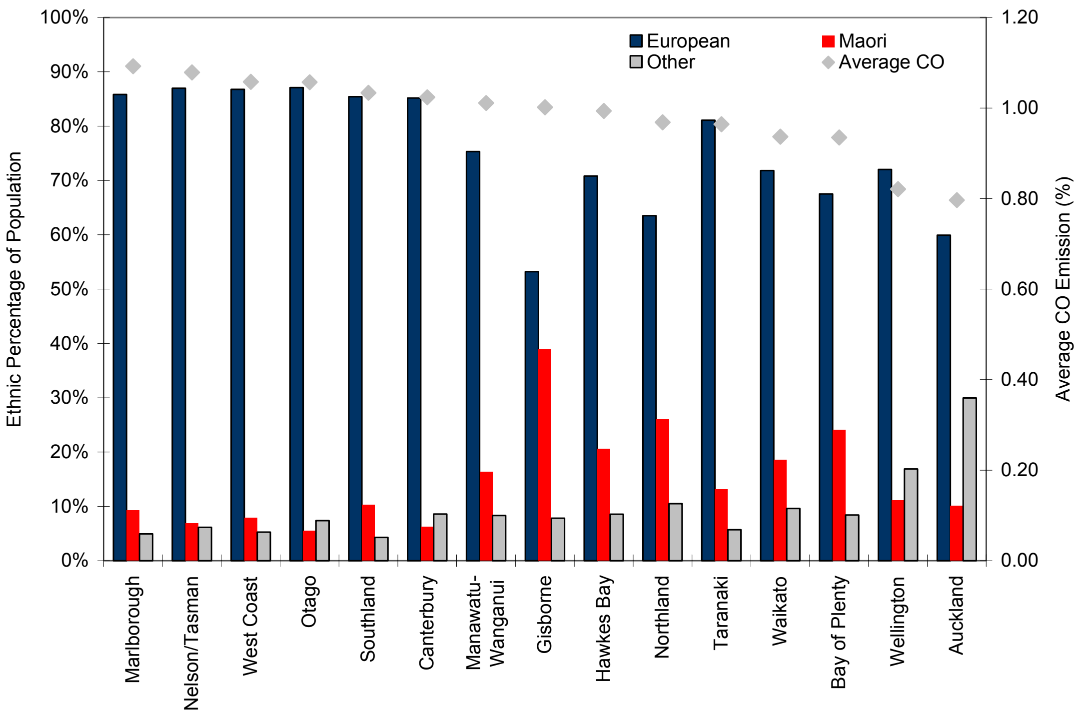


4.5. Regional Ethnicity

The data suggests that the regions with the highest emissions levels are populated mainly by Europeans, particularly in the South Island. However, it should once again be noted that within each of these regions the burden of the emissions testing is unlikely to fall evenly across ethnicities within the general population.

Stage 2 of the study will provide a much better indication of the distribution of impacts across ethnicities within each region.

Figure 29 Regional Ethnicities vs. Average CO Emissions Levels



4.6. Impacts on Vehicle Market

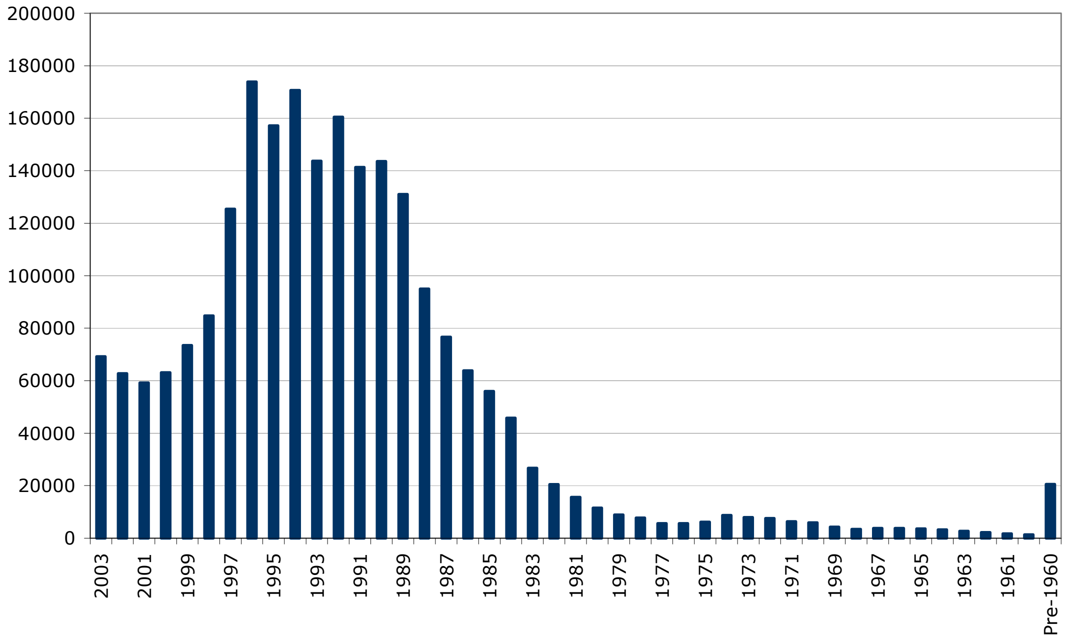
In this section we briefly comment on the likely impacts of an emissions screening programme on the vehicle market. Currently the New Zealand market is dominated by imports of Japanese second hand vehicles.

As a result of the volume of second-hand imports, the New Zealand vehicle fleet age profile is very different from that in other countries in which, assuming a growing vehicle population, there will be more new vehicles than of any other age. Figure 30 shows the current age profile of the New Zealand vehicle fleet for petrol-powered passenger cars. The highest percentage of the fleet is of 7-15 year old vehicles.

Emission tests will be expected to increase the risk of repairs for older vehicles, leading to reduced demand for older vehicles and increased demand for newer vehicles. This expected result is backed up by research in the US which suggests that increases in the average age of the vehicle fleet that occurred in the US had very little to do with the improvements in the inherent durability of the vehicles; rather it reflected reduced costs of repair and maintenance and thus reduced ongoing costs of retaining an older vehicle[37].

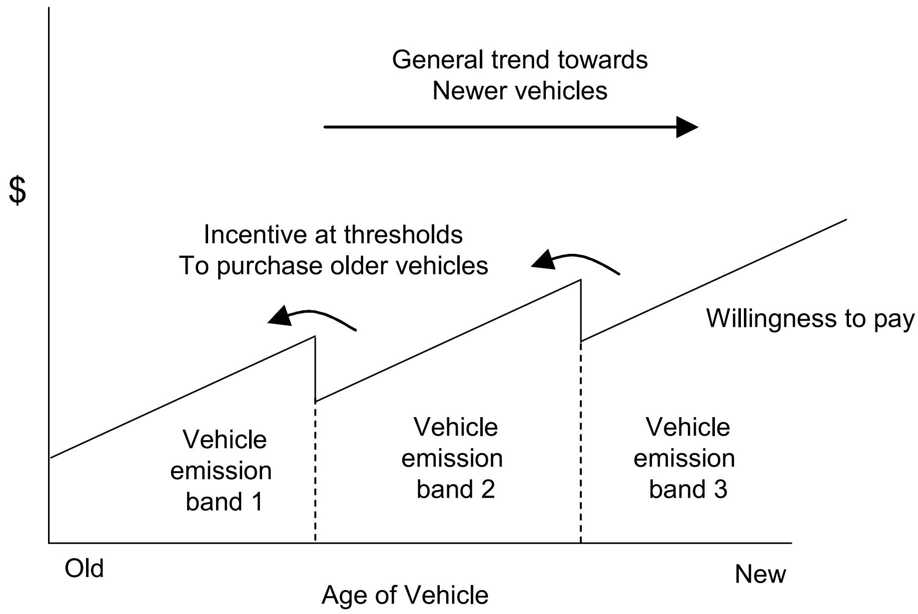
[37] Hamilton BW and Macauley MK (1998) Competition and Car Longevity. Resources for the Future Discussion Paper 98-20.

Figure 30 Age Profile of New Zealand Vehicle Fleet



This general effect needs to be qualified somewhat by the potential impact of banded cut-points (Figure 14). The effect is illustrated in Figure 31.

Figure 31 Impacts of Banding on Age Profile of Demand



The impact on vehicle prices will depend, to some extent, on changes in levels of demand; thus newer vehicle prices would be expected to rise and older vehicle prices to fall. However, Japanese imports are a substitute for current New Zealand vehicles, particularly for years that relate to the "shaken" emission test[38], ie 3, 5, 7 and 9 years old.

As there is a large fixed cost element to vehicle imports, changes in demand may have little impact on price; in a competitive market, prices will be set by supply costs which will be relatively constant across quantity imported. For older vehicles, beyond the age at which most Japanese cars are imported, prices are set through New Zealand demand and supply—there are no additional supply sources. For these vehicles prices would be expected to fall, recognising the risk of repair failure.

4.7. Impacts on small garages

The costs of testing can be passed on to motorists in the fee for a WoF or CoF, but small garages may be limited in their ability to do so because they will have fewer vehicles from which to recover the costs of the test. The US data demonstrates both that centralised facilities have a much higher throughput (more than three times) per piece of test equipment and lower test fees. The same is likely to occur in New Zealand, meaning that, for capital intensive items, small garages will be at a competitive disadvantage.

This is balanced by the potential for additional work for small garages as a result of any test failures. Vehicle failures occur for a wide variety of reasons, including:

These issues will be explored in more detail in the next phase of work.

4.8. Conclusions

This section has started from the assumption that the highest emitters and those most likely to fail, will be the oldest vehicles. The regional analysis of emissions levels is very consistent in its findings:

- Auckland and Wellington have low emissions levels relative to other regions due to their newer vehicle fleets
- North Island regions have lower average emissions levels than South Island regions
- Regions that have high CO levels also have high HC levels

The overall implication is that some regions, and particularly those in the South Island, will have a higher propensity to fail an emissions test due to the greater ownership of older vehicles. Furthermore, low income households have a higher propensity to own

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[38] New cars in Japan are sold with a "shaken", a fitness warranty that is valid for three years. At the end of those three years the shaken can be renewed, but at a substantial cost averaging around US$1500. Further renewals are required at two-year intervals. The high renewal cost leads many Japanese to replace the cars after the shaken expires, thus creating a large supply of almost-new used cars; the strict regulations translate to a higher rate of depreciation in the value of automobiles in Japan than elsewhere in the world. [Sofronis K. Clerides (2003) The Welfare Effects of Trade Liberalization: Evidence from Used Automobiles University of Cyprus/Yale University (www.econ.yale.edu/seminars/trade/tdw03/clerides-030512.pdf)]

older cars because older cars are cheaper to purchase. This implies that low income households will bear a disproportionately high share of the burden of emissions testing.

There will be some longer term impact on the vehicle market. More specifically, there will be additional incentives to purchase newer vehicles. This is likely to result in a reduction in the average age of the vehicle fleet and demand is most likely to be met through increases in Japanese imports of mid-age vehicles. The way in which emission cut-point bands are established will influence levels of demand for vehicles at different ages.

There will be impacts on small garages. On the one hand they are likely to have higher average costs of emission testing, which will make them less competitive than centralised testing stations in providing emission tests. On the other hand, undertaking emission tests is expected to increase the volume of work; this might allow them to cross-subsidise emissions testing and provide emission tests at more competitive prices.

4.9. Work in Phase II

The analysis in this phase has been provisional based on regional averages. The analysis in the next phase will be far more detailed through using data at a more geographically disaggregated level.

The analysis here suggests that lower income households are more likely to have higher emission vehicles. The extent to which this results in higher numbers of test failures depends on the way in which the emissions screening rule is written, particularly the way in which category bands are set and the coverage of the vehicle fleet.

5. Consequences of Test Failure

Our analysis of social impacts of the vehicle emissions screening programme examines the interaction between:

- **initial or first order effects**, which, if the vehicle fails the test, will be:
  - a repair bill; or
  - the costs of a replacement vehicle; or
  - loss of a vehicle. In the short term this might be because a household is waiting for the car to be fixed or to buy a replacement. In the long run, this might be because the household cannot afford the bill, or to purchase a replacement vehicle, or chooses not to, given its revised assessment of the benefits and costs of vehicle ownership; and

- **vulnerability**, related to:
  - disposable income levels, and therefore the extent to which the household can afford to pay for repairs or a replacement vehicle and maintain existing standards of living; and
  - vehicle dependency and thus how a loss of vehicle will affect the household.

There are also impacts that surround the decision of a household to avoid the bill, eg by driving a vehicle without a warrant. This can result in increased risk from safety aspects of the warrant process.

The initial effects in terms of expected repair costs and the decision to scrap a vehicle were discussed in Section 3 above. In this section we firstly discuss the issue of vulnerability. It includes an analysis of vehicle dependency and of disposable income. Secondly we examine the expected impacts on vulnerable households. The discussion of impacts focuses on two main effects:

- income-related effects; and
- social exclusion.

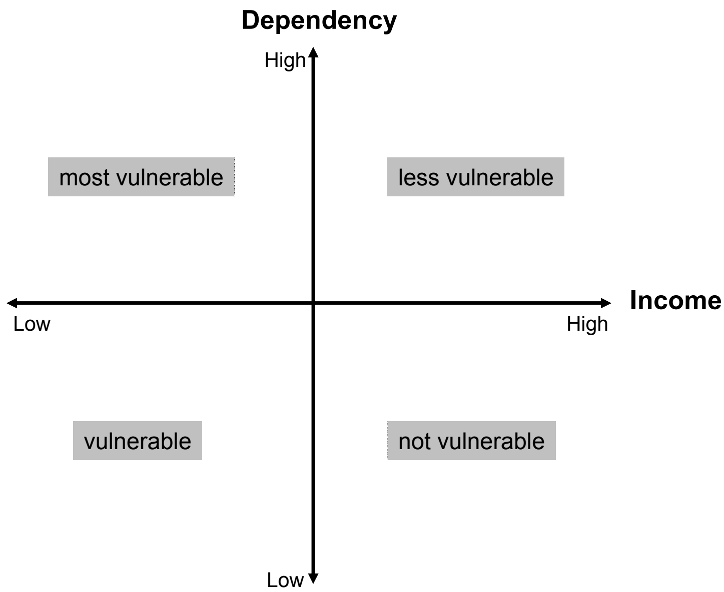
5.1. Vulnerability

The impacts of the new testing programme will differ across communities. In general, the more vehicle dependent a given community, and the lower its average household income, the greater the potential impact. The relationship between these factors is illustrated in Figure 32.

The households most vulnerable to the impacts of the screening programme are represented in the top-left quadrant. Household in the bottom-left quadrant (*i.e.* low income but lower dependency) are the next most vulnerable because, despite having lower vehicle dependence, they will face financial hardship if they incur car repair costs.

Households in the top-right quadrant are less vulnerable than those on the left-hand side but are still vulnerable due to their vehicle dependence. Households in the bottom-right quadrant are not considered vulnerable as they have low dependency and, in the event of unexpected costs, are unlikely to face financial hardship.

Figure 32 Vulnerability as a function of vehicle dependency and income



In the remainder of this section we will identify the characteristics of the two most vulnerable sets of households (ie the top-left and bottom-left quadrants) by building up profiles of vehicle dependency and income, and examining overlaps.

5.2. Vehicle Dependency

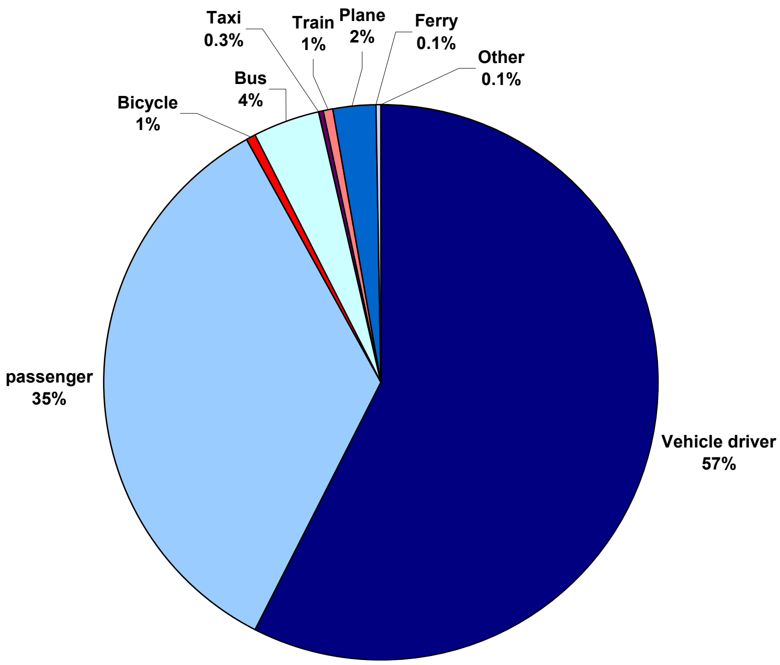
Vehicle dependency can be measured in many ways. Perhaps the easiest and most intuitive is to define it as reliance on a private motor vehicle either as a driver or passenger. Using this definition along with data from the New Zealand Travel Survey, we have identified the vehicle dependency of various groups and communities, as set out below.[39] First, however, we show New Zealand's dependence on private motor vehicle transport at the national level.

5.2.1. National Dependency

As depicted in Figure 33, private vehicles (excluding buses, trains, taxis etc) account for 92% of total kilometres travelled by New Zealanders; 57% as a vehicle driver and 35% as a vehicle passenger. The next most popular travel mode is the bus, which accounts for around 4% of total kilometres travelled. Ferries have the lowest share of 0.3%. Thus, New Zealand is highly vehicle dependent at the national level.

[39] The New Zealand Travel Survey was conducted in 1997 and 1998. Approximately 14,000 people were surveyed from 7,000 randomly sampled households and were asked to describe all of their travel by various modes for two particular days (called travel days). This is the most comprehensive survey of its kind in New Zealand and provides a wealth of information relevant to this project.

Figure 33: Modal Shares of National Kilometres Travelled



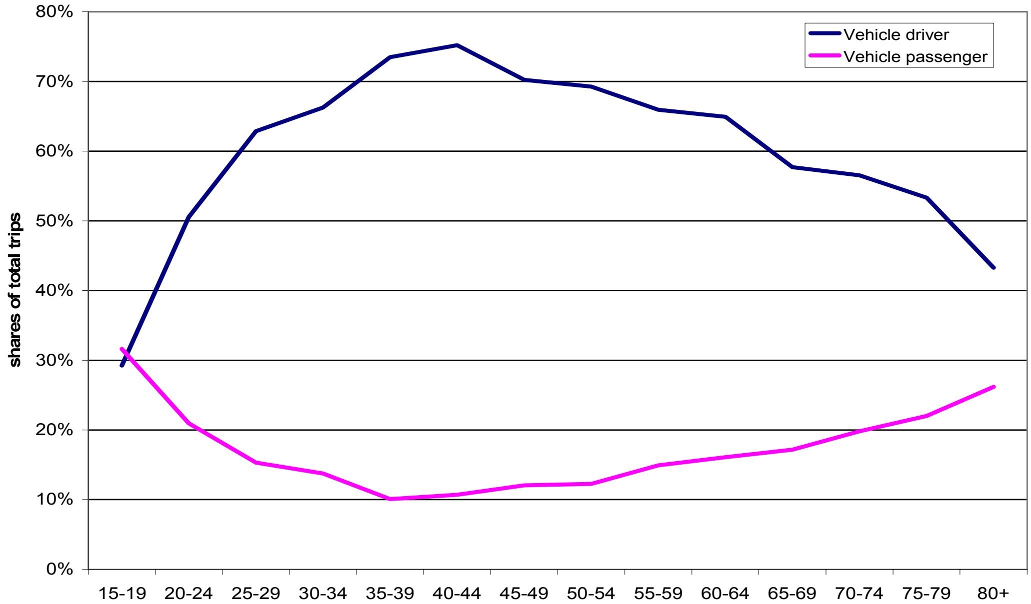
Source: New Zealand Travel Survey 1997/98

5.2.2. Age

Age appears to have a significant influence not only on private vehicle dependence, but also the proportion of such trips that are taken as a passenger or driver. This latter point is illustrated in Figure 34, which graphs shares of total trips made as a driver or passenger by age.

In the youngest age bracket (15-19 years), trips as a passenger are slightly more prevalent than trips as a driver (32% vs 29%). As age increases through to the late 30s-early 40s, shares of trips as driver increase and shares of trips as passenger decrease. Beyond this age group the trend is reversed, with passenger travel becoming more important and driver travel less important. For the oldest age group, driver travel remains more important than passenger travel accounting for 43% and 26% of total trips, respectively.

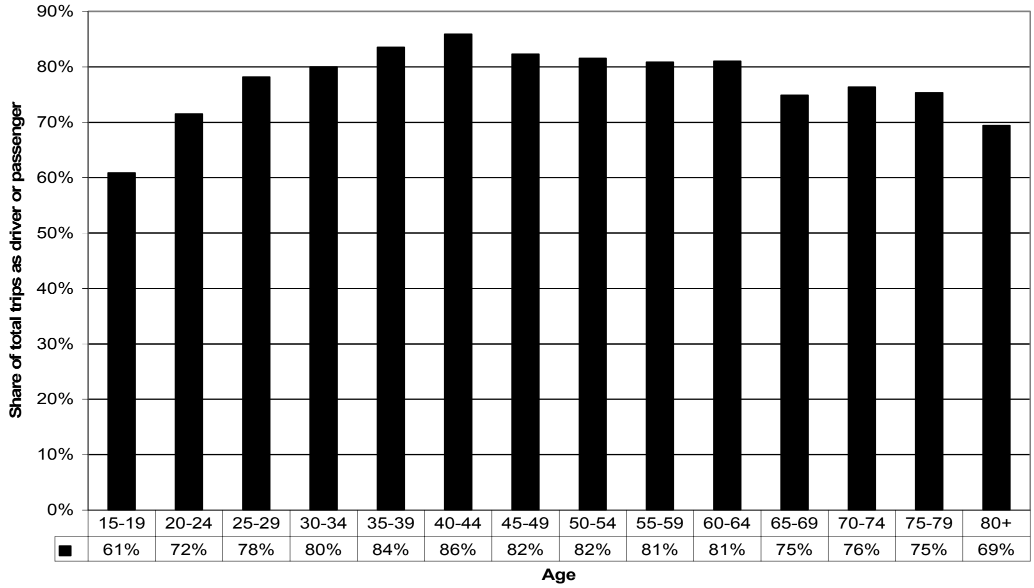
Figure 34: Share of total Trips as Passenger and Driver by Age Group



Source: New Zealand Travel Survey 1997/98

Total vehicle dependence, which is dependence either as a driver or passenger, is less variable with age. This is shown in Figure 35, which graphs share of total trips made in a private vehicle; 15 to 19 year olds are the least vehicle dependent, with only 61% of total trips made in this mode of transport. This increases up to early 40s, where dependence peaks and 86% of trips are made in private motor vehicles. Dependence then declines, with over two-thirds of total trips by people aged 80+ being in a private motor vehicle.

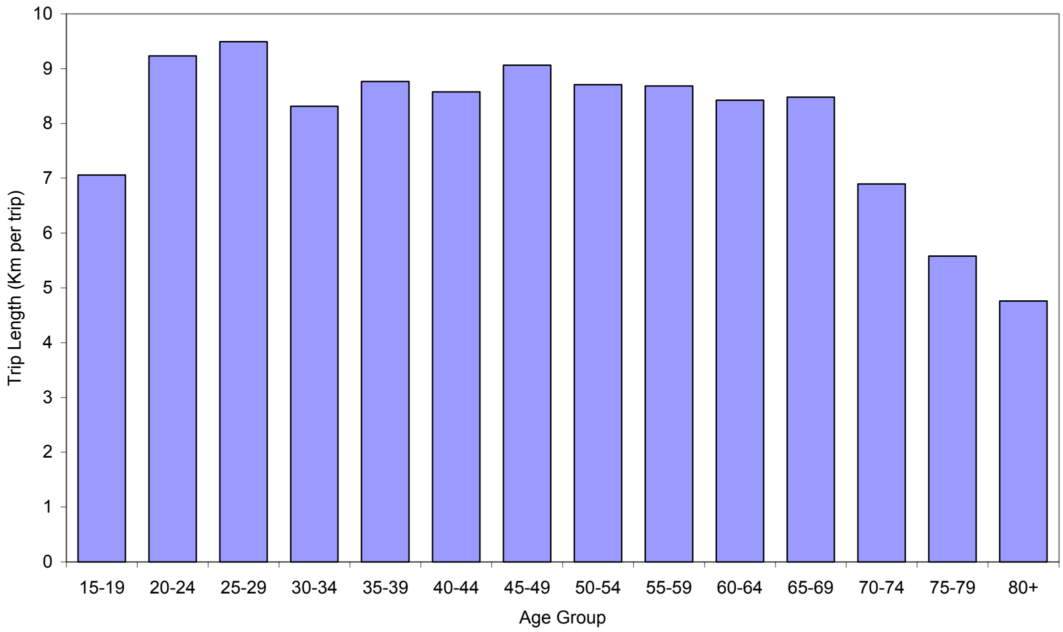
Figure 35: Vehicle Dependence by Age



Source: New Zealand Travel Survey 1997/98

Figure 36 shows the change in average trip distance with age of driver. As for the proportion of trips by vehicle, the trip distance falls off at old age. However, younger age groups (20-29 years) have the largest trip distances.

Figure 36 Trip Distance with Age



Source: New Zealand Travel Survey 1997/98

The data suggest that middle aged people are the most vehicle dependent with young and old people less dependent.

5.2.3. Gender

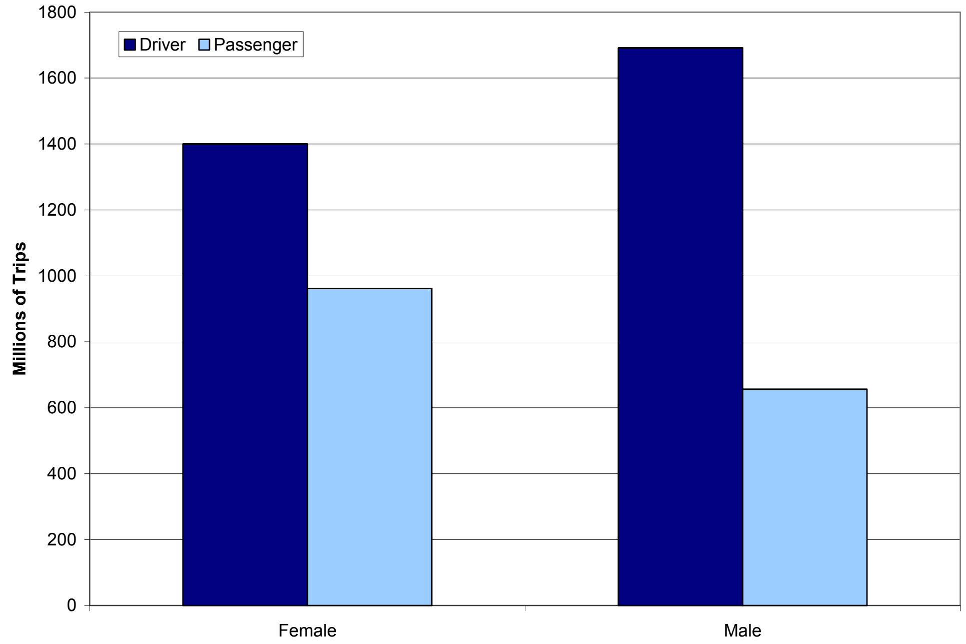
Men and women appear to be equally dependent on private motor vehicles, although men are more dependent as drivers and women are more dependent as passengers. Both make around 2.3 billion trips per annum in total. This is illustrated in Figure 37.

5.2.4. Region

Vehicle dependency, measured as kilometres travelled per person as either a driver or passenger, differs markedly across regions. Northland has the highest driver and passenger dependency, with each person travelling nearly 18,000 kilometres per annum in a private car, van or truck. Other highly dependent regions are Bay of Plenty, Waikato, Taranaki and Southland. This probably reflects the relatively rural nature of these areas and, therefore, the longer average length of each trip.

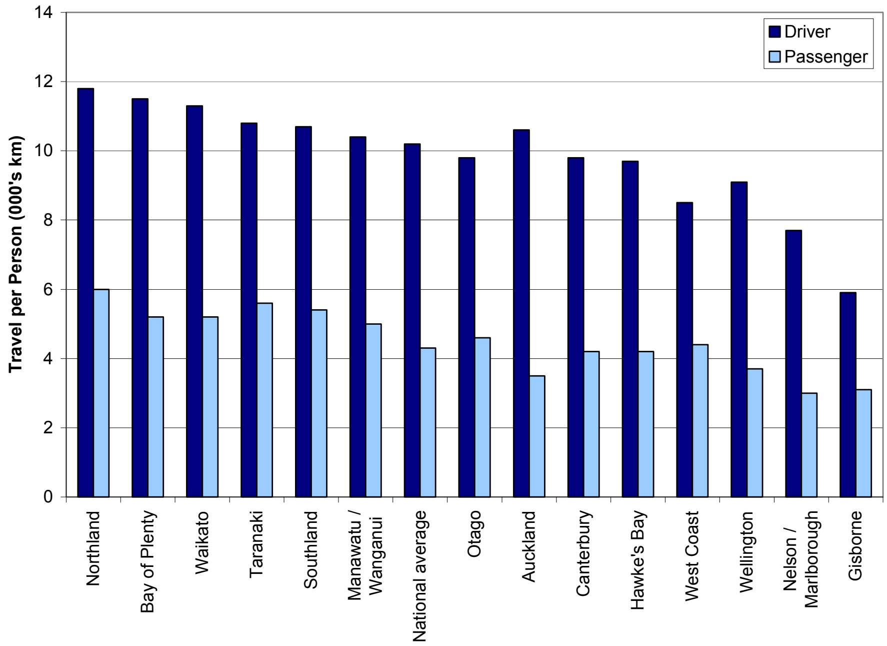
Gisborne is the least vehicle dependent region, with each person travelling only 9,000 kilometres per year as a driver or passenger. Next is Nelson/Marlborough, followed by Wellington and the West Coast.

Figure 37: Millions of Trips as Driver or Passenger by Gender



Source: New Zealand Travel Survey 1997/98

Figure 38: Average Distance Travelled per Person by Region (000s km)



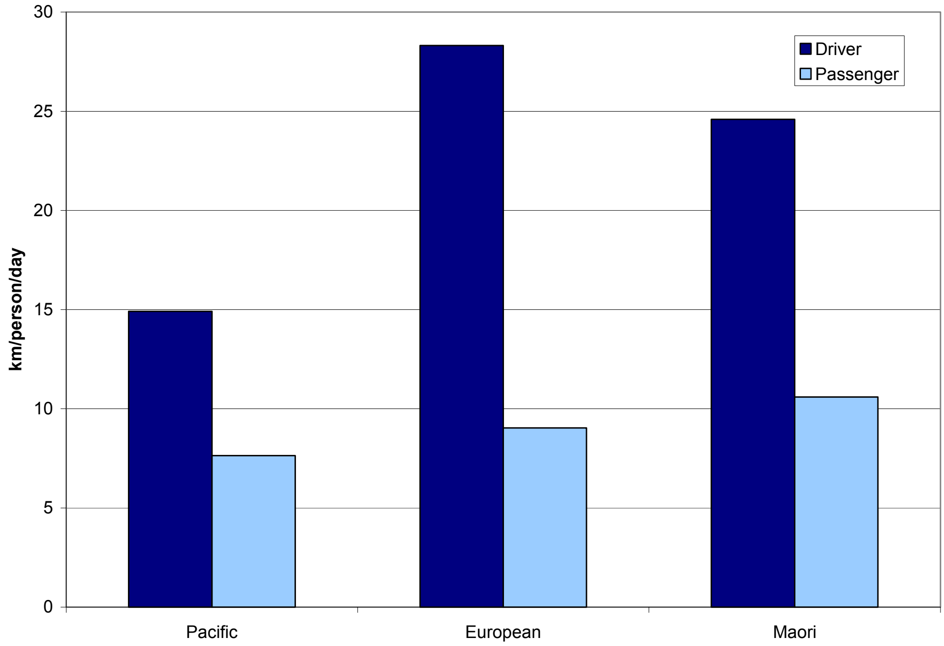
Source: New Zealand Travel Survey 1997/98

5.2.5. Ethnicity

Figure 39 shows how vehicle dependency differs amongst the 3 major ethnic groups – European, Maori and Pacific Islanders. The dark blue bars represent kilometres travelled per person per day as a driver and the light blue as passenger.

Europeans appear to be the most dependent as drivers and Maori are the most dependent as passengers, but overall they are roughly the same as Europeans (*i.e.* the totals for driver and passenger are about equal). Pacific Islanders are less dependent on private vehicles in both capacities, particularly as drivers. Thus Europeans and Maori are the most dependent races.

Figure 39: Dependency by Ethnicity



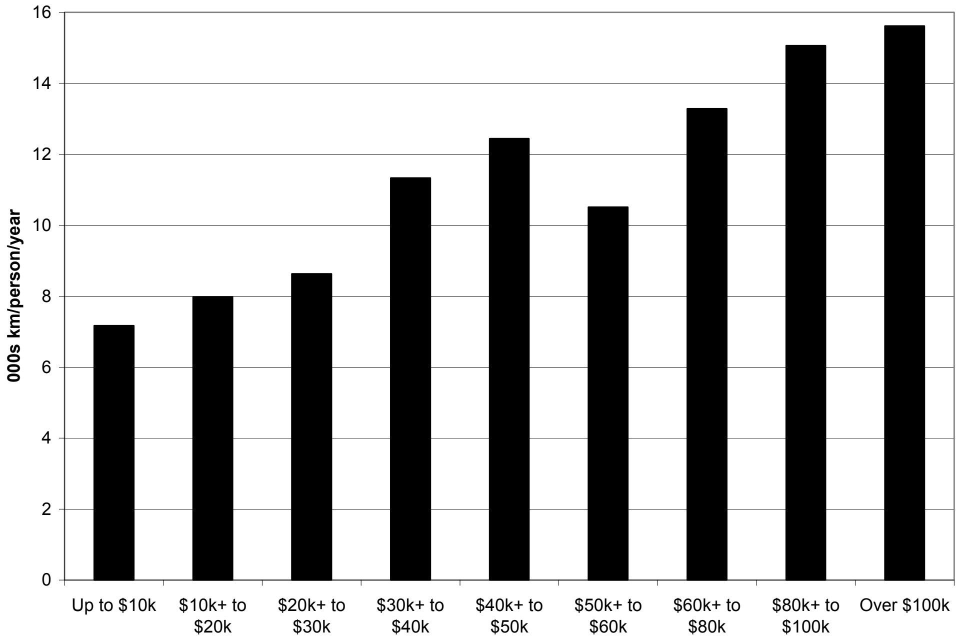
Source: New Zealand Travel Survey 1997/98

5.2.6. Income

Finally, we investigate the relationship between vehicle dependency and household income. This is probably the most important of all the dependency profiles, because it provides a direct link between the two factors that determine 'vulnerability'.

According to Figure 40, there is a fairly strong and positive relationship between household income and vehicle dependency. The one exception to this general trend is that dependency amongst $50,000-$60,000 income households is lower than expected.

Figure 40: Dependency by Household Income



Source: New Zealand Travel Survey 1997/98

5.3. Income

The vulnerability of a given community to the screening programme would be determined not only by its vehicle dependency, but also by its ability to meet unexpected repair costs in the event of a test failure. Accordingly, this section investigates New Zealand's income distribution by age, gender, region and ethnicity.

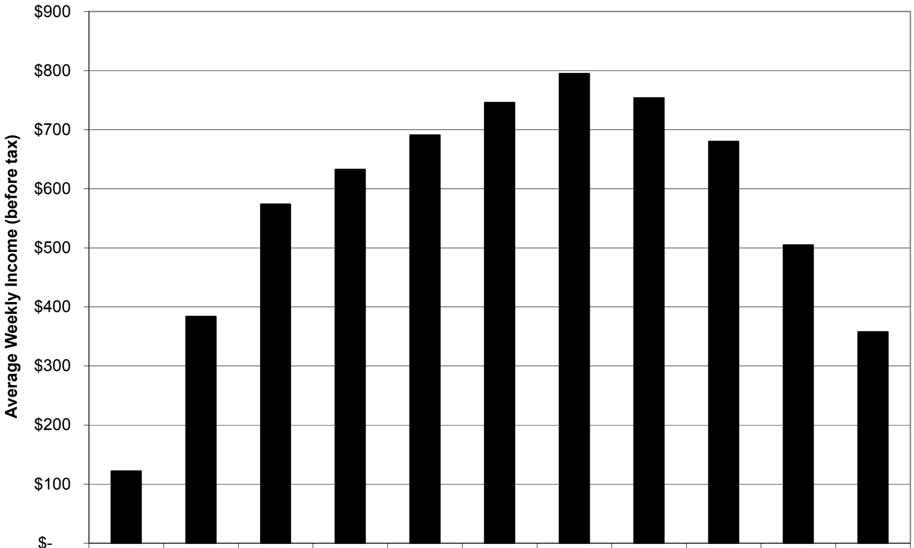
While the relevant unit of analysis for this project is the household, it is not practical to analyse household income distributions in this way because there is no information to support it.[40] Instead, we rely on personal income distributions to understand demographic, ethnic and geographic variations. While not a perfect proxy for household income, personal incomes provide a fair indication of the underlying trends.

5.3.1. Age

Figure 41 presents average weekly personal income before tax by age group. As with vehicle dependency, average income is lowest in the 15-19 year old bracket and increases rapidly with age. Unlike vehicle dependency, however, personal income peaks in the 45-49 year bracket (rather than 40-44). After age 50, average weekly income steadily declines.

[40] The only exception is household income by region, which can be obtained from the 2001 census. All other information in this section has been taken from the New Zealand Income Survey June 2004.

Figure 41: Average Weekly Income before Tax by Age Group



	15-19	20-24	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64	65 +
■	$122	$384	$574	$633	$691	$746	$795	$754	$680	$505	$358

Source: New Zealand Income Survey June 2004

5.3.2. Gender

As has always been reported, average weekly male incomes are far higher than those of females; the average weekly income of males before tax was $700 for the year ended June 2004, while for females it was only $417 [41]. This inequality is a reflection of many complex and interrelated factors, a detailed discussion of which is beyond the scope of this paper.

5.3.3. Region

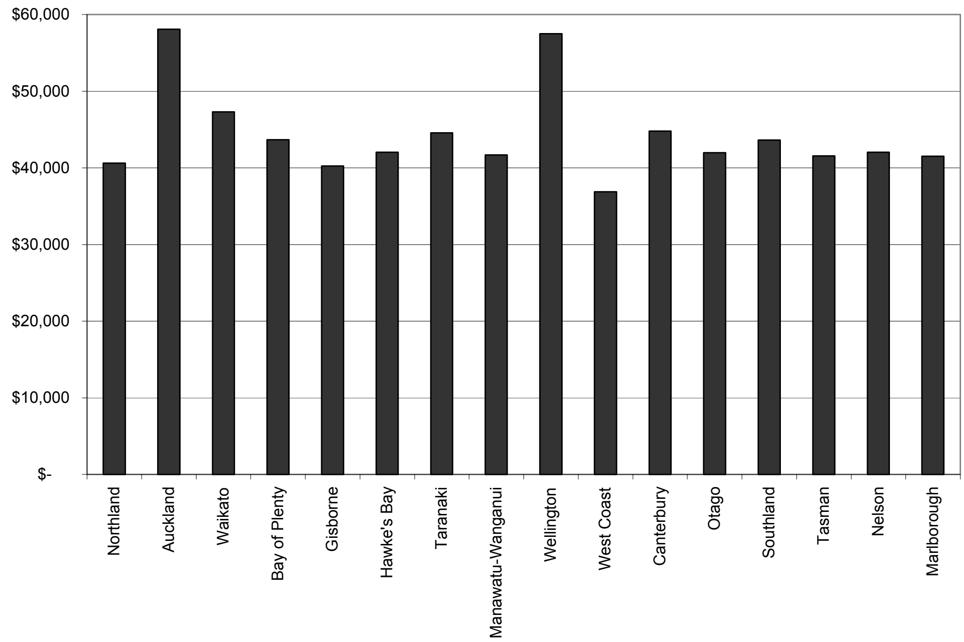
Figure 42 shows average annual household income before tax by region. Barring Auckland and Wellington, income variations are relatively small across regions. Auckland and Wellington appear to be outliers, both having much higher average household incomes that other areas of New Zealand. Overall, Auckland has the highest household income of just over $58,000, while the West Coast has the lowest (just under $37,000).

5.3.4. Ethnicity

The final income distribution that we investigate is income by ethnicity. This is illustrated in Figure 43. Europeans/Pakeha have the highest average income ($600 per week), followed by Maori ($437), other ($402) and Pacific peoples ($381).

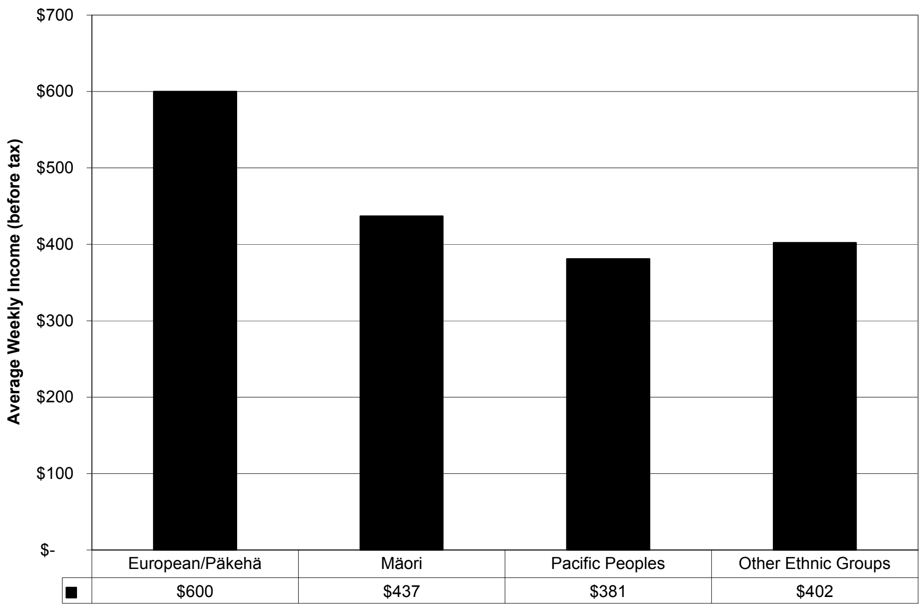
[41] Zealand Income Survey June 2004

Figure 42: Average Annual Household Income by Region



Source: Census 2001

Figure 43: Average Personal Income before Tax by Ethnicity

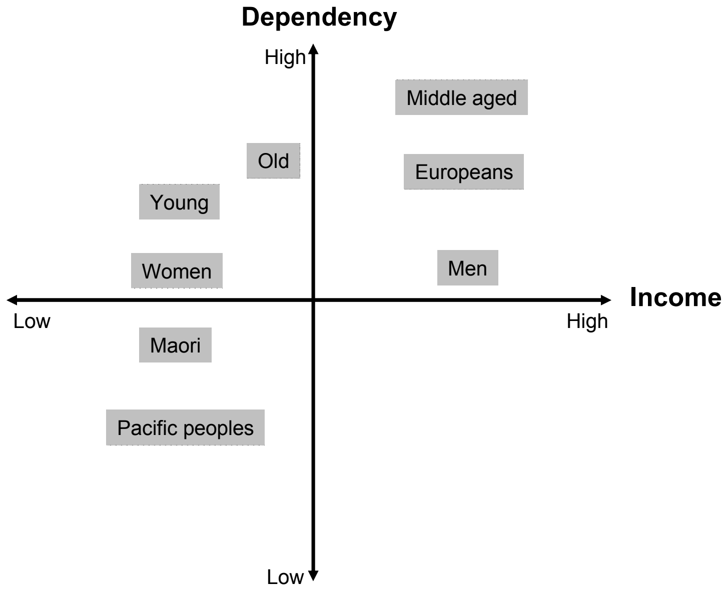


Source: New Zealand Income Survey June 2004

5.4. Vulnerable Groups

The preceding sections have identified variation in vehicle dependency and income across various sectors of New Zealand. Of particular interest to this study is the extent to which these variations are correlated. Using the quadrant diagram from Figure 32, we have cross-tabulated the results of the preceding section to identify communities at greatest risk (Figure 44).

Figure 44: Ranking of Communities at Risk



Our analysis suggests that the communities at greatest risk from the proposed programme are young and old people, particularly of Maori and Pacific descent. Europeans, while more vehicle dependent than other ethnicities, are considered to be at lower risk due to significantly higher average incomes; and middle-aged people that have a greater vehicle dependence than young and old people, similarly have higher incomes on average.

In the New Zealand literature that identifies groups which are at particular risk of poverty and social exclusion, focussing on families, Maori and Pacific Island families, lone parent families and two parent families with three or more children are consistently identified as being at risk[42]. On a headcount basis, Pakeha families are

[42] Easton, B. (1994) *Poverty in New Zealand*. Wellington, Economic and Social Trust on New Zealand; Krishnan, V. (1995) "Modest but Adequate: An Appraisal of Changing Household Income Circumstances in New Zealand" in *Social Policy Journal of New Zealand* (4) 76-97; Easton, B. (1995) "Poverty in New Zealand: 1981-1993" in *New Zealand Sociology* 10 (2) 181-213; Waldegrave, C., Frater, P. (1996) 'New Zealand: A Search for a Poverty Line' in Oyen, E., S. Miller, S. Oslo, Scandinavian University Press; Waldegrave, C., Stephens, R., Frater, P. (1996) "Most Recent Findings in The New Zealand Poverty Measurement Project" in *Social Work Review* 8 (3): 22-24; O'Brien, M., Briar, C. (eds) (1997) *Beyond Poverty.* Auckland, Auckland Unemployed Workers Rights Centre; Waldegrave, C., Frater, P., Stephens, B. (1997) "An Overview of Research on Poverty in New Zealand" in *New Zealand Sociology* 12 (2: 213-259; Stephens, R. (1999) 'Poverty, Family Finances and Social Security' in Boston, J., Dalziel,P., St. John, S. *Redesigning the New Zealand Welfare State*. Auckland, Oxford University Press; Crampton, P., Salmond, C., Kirkpatrick, R. (with Scarborough, R., Skelly, C.) (2000) *Degrees of Deprivation. An atlas of socioeconomic difference*. Auckland, David Bateman; Ministry of Social Development (2001) *The Social Report*. Wellington, Ministry of Social Development; St John, S., Dale,

numerically the largest group, however, the proportion of Maori and Pacific Islands families living in poverty and with lower living standards is greater. The work from the Ministry of Social Development notes that living standards among families are lower than among the retired population[43]. Its research also notes that the beneficiary population generally is more highly represented among those with lower living standards.

For the groups that are most at risk we explore the likely impacts. Firstly we look at the direct income-related effects. Secondly we examine the issue of social exclusion. We then examine some of the individual groups and the expected impacts.

5.5. How will Households Accommodate a Cost Spike?

If a car fails the new emissions test, households will have three main options:

- repair the vehicle and have the car retested;
- purchase a replacement vehicle; or
- live without a vehicle.

If the household chooses to repair the car or purchase a replacement, it will be faced with a sudden increase in household living expenses.[44] In this section we investigate how households might accommodate such a cost spike—how will the household budget be altered to finance the cost and what items of expenditure will be affected in the process?

It should be acknowledged at the outset that it is very difficult to predict with any certainty how households will meet unexpected increases in living costs. For most households, however, they are likely to reduce spending on items across the board, but with smaller reductions on core items such as food and housing.

Before trying to predict the changes in household expenditure that will accompany an unexpected cost increase, we first profile the current spending patterns of households using data from the Household Economic Survey 2003/04. This provides some insight into the ability of households to meet cost increases from savings and the extent to which they will need to divert expenditures on other items to pay the bill.

C., O'Brien, M., Blaiklock, A., Milne, S. (2001) *Our Children. The Priority for Policy*. Auckland, Child Poverty Action Group; Blaiklock, A., Kiro, C., Belgrave, M., Low, W., Davenport, E., Hassall, I. (2002) *When The Invisible Hand Rocks The Cradle: New Zealand Children in a Time of Change*. Florence, Unicef Innocenti Research Centre;

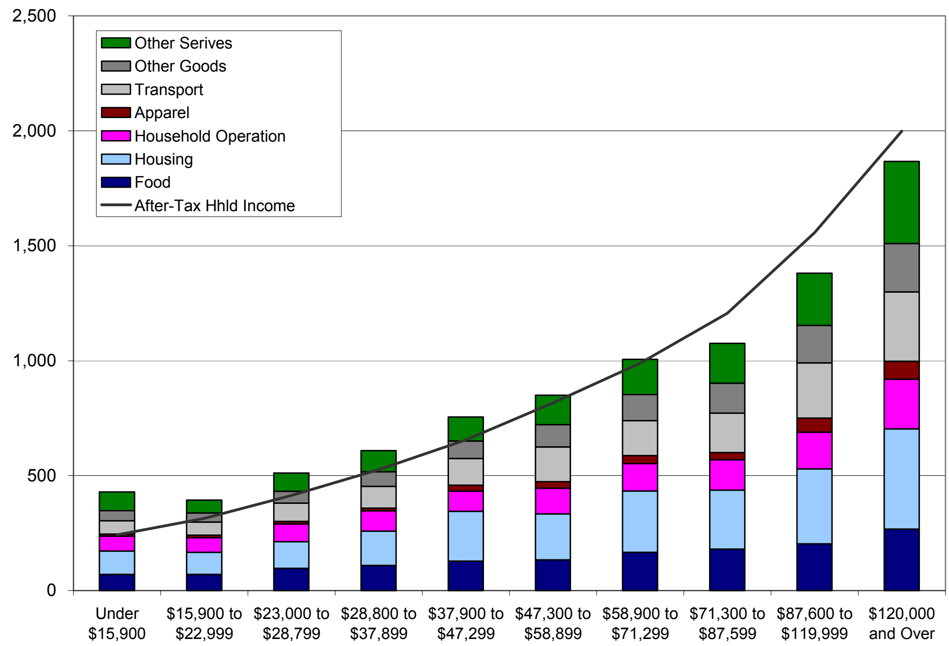
[43] Krishnan, V., Jensen, J., Ballantyne, S. (2002) *New Zealand Living Standards 2000*. Wellington, Ministry of Social Development

[44] Even if they choose to scrap the vehicle, they will be faced with costs increases, such as the costs of switching to another travel mode or the cost of a replacement vehicle. The actual source of the cost increase is immaterial for this section of the analysis. We are merely interested in the way that households will accommodate an unexpected increase and the impact that it will have on household expenditures (and therefore welfare).

The Household Economic Survey (HES) is a triennial survey of household income and expenditures. It provides a comprehensive picture of the spending patterns of households by income bands and is a key input to social policy work. Figure 45 graphs one of the most important datasets gleaned from this survey - average weekly expenditure against disposable household income. Not only does this graph show the general relationship between income and expenditure, it also shows the composition of expenditures. The importance of this latter point will soon become evident.

Figure 45 shows that many households are currently living outside their means because total expenditures (the bars) exceed disposable income (the line). Only households in the three highest income bands have higher income than expenditure. This suggests that many New Zealand households are rapidly accumulating debt in order to finance their daily standard of living. It also implies that, for most households, a sudden increase in living costs can not be met from income.

Figure 45: Average Weekly Income and Expenditure (NZ**$**)



The expenditure figures outlined above are disaggregated into seven groups: food, housing, household operation, apparel, transport, other goods and other services. The first five categories represent core household expenditure and the latter (top) two represent more discretionary expenditure.[45]

In addition to highlighting the net deficit position of many households, the graph also shows that a high proportion of weekly expenditure (in each income band) is on core expenditure, with only a small proportion on discretionary items. This suggests that

[45] The last two expenditure categories are labeled 'other goods' and 'other services', respectively. They cover items such as tobacco, alcohol, gambling, recreation, health services, insurance, and so on.

many households do not have significant discretionary income from which to meet a sudden increase in living costs. Instead, they will be forced to reduce expenditure on core items if they are to foot the bill.

This point raises an important question—which particular items are most likely to be reduced in order to meet a sudden repair bill and what impact will this have on a household's standard of living? Unfortunately, the answer to this question can not be ascertained from the HES. It does not provide a priority ranking for expenditure items from which a schedule of likely reductions can be estimated.

In order to address this question, we have drawn on the work of Michelini who has done pioneering work on New Zealand household consumption patterns. Michelini[46] uses HES data from 1983 to 1992 to estimate a series of household demand equations (Table 13). These show how demand for goods and services (which span the last 6 of the 7 categories in Figure 45) are related to prices and household income changes.[47]

Table 13: Michelini Estimates of Income Elasticity

Expenditure Group	Income Elasticity
Food	0.558
Household Operation	0.747
Apparel	1.110
Transport	1.276
Other Goods	1.095
Other Services	1.321

Source: Michelini C (1999) New Zealand Household Consumption Patterns 1983-1992: An Application of the Almost Ideal Demand System", N.Z. Economic Papers, 33 (2), 15-26

Michelini used these household demand equations to derive income elasticity estimates. These show how consumption of each of the major expenditure categories in the HES change as household income changes. These have direct application to the task at hand; by interpreting a sudden repair bill as an unexpected fall in household (disposable) income, we can apply the Michelini elasticity estimates to infer how consumption of other goods will change to foot the bill.

All elasticities are positive, which means that consumption of each item increases as income increases, and vice versa. Moreover, elasticity is lower for truly essential items, such as food and housing and higher for more discretionary items such as 'other goods' and 'other services'. Interestingly, however, the elasticity of transport is higher than that of all other items apart from 'other services', which suggests that transport will be one of the items for which expenditure will be reduced—given the choice, households are likely to choose to live without a vehicle rather than reducing expenditure elsewhere.

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[46] Michelini C (1999) New Zealand Household Consumption Patterns 1983-1992: An Application of the Almost Ideal Demand System", N.Z. Economic Papers, 33 (2), 15-26

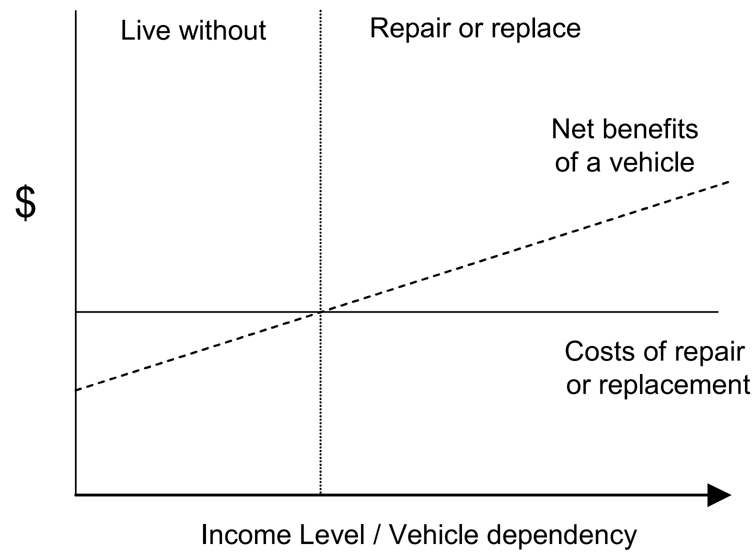
[47] Michelini excluded the Housing expenditure group because (at that time) it covered the sale and purchase of property and distorted the analysis. This omission is immaterial for our purposes, because expenditure on housing (other than sale and purchase) is considered highly invariant with respect to household income. In other words, housing choices are essentially fixed in the short term and so income changes are unlikely to affect housing choices, at least in the short to medium term.

At this stage it is difficult to say anything more conclusive about how households will accommodate a spike in living costs caused by an unexpected car repair bill. We postulate some impacts in Section 5.7. It is expected that information elicited from focus group discussions in the next phase of this project will provide more detailed information.

5.6. Impacts of Vehicle Loss—Social Exclusion

For many households, the prospect of an unexpected car repair bill is daunting. While some will accommodate it through tighter budgeting, many will simply choose not to repair or replace. The choice on whether to repair or replace versus living without can be seen as a cost benefit decision at the household level (Figure 46). The net benefits of a vehicle are more likely to exceed the costs of repair or replacement for households with higher income or greater vehicle dependency. The net benefits of the vehicle include the opportunity costs of having one, ie what the household gives up to have a vehicle. Where there is a direct impact on other household expenditure that is highly valued then the net benefits of having a vehicle will be lower and households are more likely to choose to live without.

Figure 46: Cost-Benefit Decision



Household may experience a significant loss of mobility if they do not have access to alternative transport, such as a second vehicle. The actual impacts of losing a car depend on a number of factors, including household structure, the degree of vehicle dependence, social networks, public transport options, location, and so on.

There is a growing body of literature that examines the relationship between social exclusion and access to transport. There are a number of definitions of social exclusion, but very largely they refer to factors that restrict people from normal activities of citizens. UK researchers define it as "people are excluded from activities they wish to undertake

- spatially, because they cannot get there at all,

- temporally, because they cannot get there at the appropriate time,
- financially, because they cannot afford to get there, and
- personally, because they lack the mental or physical equipment to handle the available means of mobility.[48]"

In the UK, a review of relevant literature found that the social exclusion problem related to transport included the following components[49]:

- *Access to work:* lack of transport can be a barrier to retaining and getting a job.

- *Access to learning:* reduced access to private transport can limit individuals' ability to get to educational establishments, especially for tertiary and adult education.

- *Access to healthcare:* hospitals and other medical facilities may not be easily accessed.

- *Access to food shops,* particularly supermarkets.

- *Access to social, cultural, and sporting activities:* including seeing friends and family, getting to sports centres and libraries.

Many advocates of public transport claim that losing a car is softened by the availability of public transport. However, there are also strong opinions to the contrary. First, public transport offers limited travel flexibility and has limited coverage. In many areas, it simply does not exist. Second, even if public transport options are available, certain groups of people will not consider it a feasible alternative. Barriers to use include physical (particularly for children, elderly, disabled, those with shopping and young children), distance from public transport stops, distance and journey time to the destination, costs of individual trips, time constraints of public transport, fear about safety[50].

5.7. Potential Impacts on Vulnerable Groups

Table 14 summarises the expected vulnerabilities for different groups that are identified in this section. The issues are discussed in more detail below.

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[48] Church A, Frost M, and Sullivan K, (2000) Transport and social exclusion in London, Transport Policy 7, pp195-205 in: UK Commission for Integrated Transport Obtaining Best Value for Public Subsidy for the Bus Industry: LEK Research (www.cfit.gov.uk/research/psbi/lek/a3/index.htm)

[49] Social Exclusion Unit (2003) Making the Connections: Final Report on Transport and Social Exclusion. Office of the Deputy Prime Minister

[50] Church, A, Frost, M and Sullivan, K (Unpublished) Transport and Social Exclusion in London - Report Summary London: London Transport Planning in: Scottish Executive (2001) The Role of Transport in Social Exclusion in Urban Scotland. (http://www.scotland.gov.uk/cru/kd01/blue/rtseuc_01.htm)

5.7.1. Old

Older people are included in the quadrant of those most at risk because of the significance of the motor vehicle in their daily activities and hence the consequent risk of social exclusion should they be faced with losing their motor vehicle. Older people have low incomes compared with other age groups—lower than all but the 15-19 year old age group (Figure 41). Inclusion of older people as a group here also reflects the wider focus associated with the "social exclusion" approach in contrast to the data emanating from research on "living standards". The latter is, by definition, appropriately more narrowly constrained. While the older population is not so strongly identified as being among the group with lowest living standards, there is still a significant proportion of that population who do have lower living standards[51].

Table 14 Impacts on Vulnerable Groups

Group	Uses affected					Vulnerability
	Work	Education	Shopping	Social/recreational	Medical/dental	
Old			✓	✓	✓	Old people have relatively low incomes. Independence from others is an important component of quality of life; this is reduced by vehicle loss, with the potential for reduced social interaction. They are particularly vulnerable to missed hospital and dental appointments
Youth		✓	✓	✓		Youths have low personal incomes although they often will be most affected by household incomes. They value transport independence but often have a relatively wide range of transport options.
Low income	✓			✓	✓	Low income will exacerbate vulnerabilities relating to vehicle dependence.
Maori	✓			✓	✓	Vulnerability related to low income. Vehicle dependency similar to European.
Pacific People	✓			✓	✓	Vulnerability related to low income. PPs are less vehicle dependent than Maori and Europeans.
Solo parent	✓	✓	✓	✓	✓	Vulnerability related to low income. Children also affected.
Large family	✓	✓	✓	✓	✓	Vulnerability related to low income. Wide range of children and others affected.
Disabled	✓	✓	✓	✓	✓	Disabled people are more vulnerable than able-bodied people in all categories. Loss of a vehicle will reduce their ability to travel and their social participation across a wide range of activities.

[51] Fergusson, D., Hong, B., Horwood, J., Jensen, J., Travers, P. (2001) *Living Standards of Older New Zealanders. A Summary*. Wellington, Ministry of Social Policy

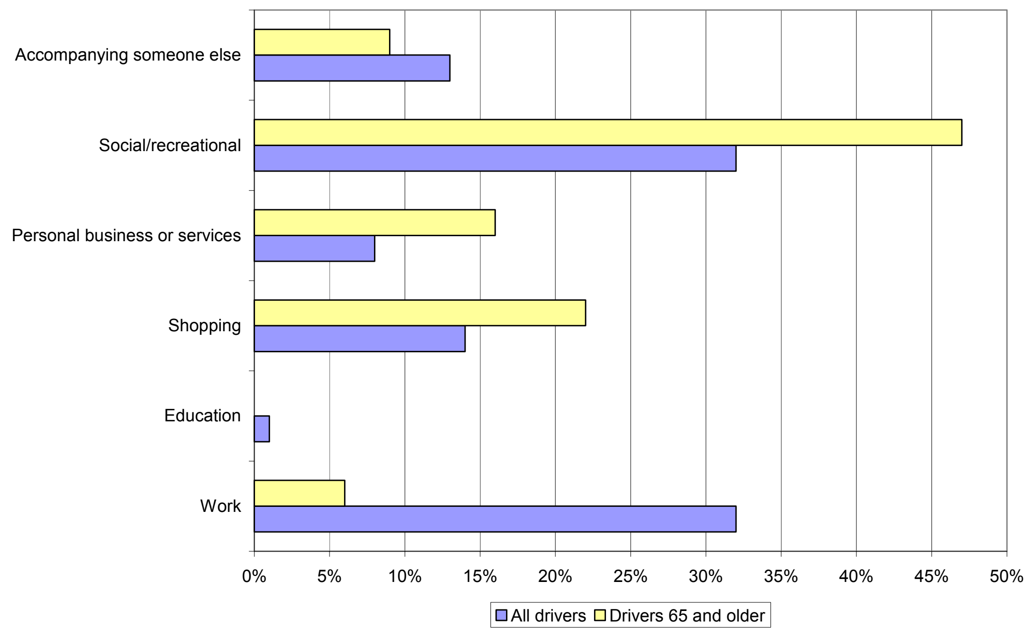
A recently-published New Zealand report entitled "Coping without a car" addresses the impact that loss of a car has on senior citizens. [52] It raises a number of relevant points. For instance, it concludes that the impact of losing a car is greater for men than women because women generally have better social networks and are more used to being passengers. Men, on the other hand, place greater importance on independence and are more reticent to ask for a lift. The report also notes that, at least in New Zealand, there is limited knowledge and uptake of community transport schemes run by volunteer agencies. This suggests that education on alternatives may help ease the burden of losing a car.

The report notes that the values of independence and autonomy are very important for quality of life in old age, so loss of mobility can have a significant impact.

Another point canvassed in the "Coping without a car" report is that, like household expenditure, most reasons for travel can be classified as either core or discretionary. The authors note that most displaced senior citizens are more likely to ask for a lift for core activities but are reluctant to do so for more discretionary journeys. Thus the loss of a vehicle manifests itself as a loss of enjoyable activities and a greater degree of social exclusion (as concluded in the international literature).

The reasons for vehicle trips differ between older people and the average population. Results from the NZ Travel Survey are given in Figure 47. The differences include greater proportions of social and recreational travel, shopping and personal business or services, and a smaller proportion of work and education. Reductions in any or all of these types of trips can adversely affect quality of life.

Figure 47 Reasons for Trips by Age (old versus all drivers)



Source: New Zealand Travel Survey (www.ltsa.govt.nz/research/travel-survey/reasons-for-travel.html)

[52] Available on the web at: http://www.osc.govt.nz/documents/coping-without-a-car-full-report.pdf

We would expect to see reduced social interaction and more staying at home. This may have impacts on overall health.

The travel survey data are not analysed for medical and dental visits as they are for youth (Figure 48). Attending medical appointments is a particularly important issue for the elderly. Researchers[53] have noted the amount of organisation required in doing so without a vehicle, either via public transport or arranging a lift with friends or family.

Important areas of vulnerability for older people are likely to be those of reduced social interaction, fewer opportunities to shop and missed medical appointments. The key issues that might be explored further via focus groups and additional research include:

- the likelihood and impact of missed medical and dental appointments;
- whether reduced shopping ability would reduce the quality of that consumed or lead to higher costs, eg through limiting access to supermarkets;
- the issue of mobility itself and its importance to quality of life;
- formal and informal arrangements that would enable transport arrangement;
- importance of transport for social and recreational purposes and the relationship to quality of life.

5.7.2. Youth

While young people are not identified in any of the research as having systematically low living standards or as being particularly vulnerable to poverty, the Ministry of Social Development report on household living standards notes that the mean disposable income for the 18 to 24-year-old age group in their research was less than $10,000[54].

They are expected to be vulnerable for two main reasons, both related to low incomes:
- they are more likely to own a motor vehicle which does not meet the required standards;
- they are expected to be vulnerable to the effect of the loss of a motor vehicle because of its effect on their social participation, including educational and social activities.

Loss of vehicle can affect young people who are passengers rather than drivers; they may be dependent on vehicle travel for wider aspects of social participation.

Figure 48 shows the reasons for trips by age category—it differentiates the reasons for trips by children and youths from those of adults. Amongst trips taken, youths are more likely to take trips for social or recreational reasons and, in comparison with adults, use vehicles to go to educational establishments rather than to work.

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[53] Hamilton K and Gourlay M (2002) Missed hospital appointments and transport. Transport Studies Unit. University of East London.
[54] Krishnan, V., Jensen, J., Ballantyne, S. (2002) *New Zealand Living Standards 2000*. Wellington, Ministry of Social Development

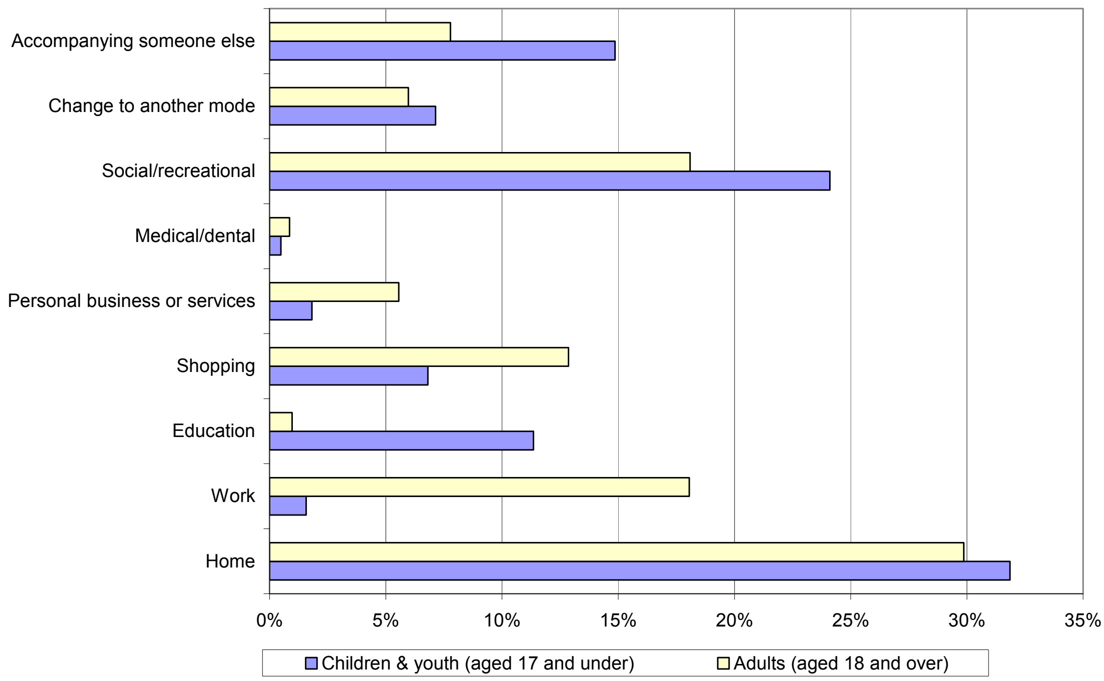
Research in New Zealand has examined the impacts of raising the driving age; this provides some insights into the dependence of young people on vehicles[55]. Although the research concluded that youths had transport alternatives, including buses, walking, cycling and family drivers, there was a strong desire to be transport-independent. Also of note, the researchers found that socio-economic status was a more important variable than rural-urban split in defining the level of private vehicle use.

There are mixed messages about the expected impact on the young and some reason to expect that they may be better able to adapt to life without a vehicle, despite the importance of transport independence. Noteworthy here, youth car use can have greater external costs including those associated with the high accident rates amongst young drivers. Reducing youth access to vehicles may have adverse impacts on this group but positive outcomes for wider society.

Focus group issues will include:

- understanding travel options;
- the importance of vehicle use in social inclusion;
- the importance of personal versus household income.

Figure 48: Reasons for Vehicle Trips by Age (children & youth versus adults)



Source: Land Transport Safety Authority (2000) Travel Survey Report 1997/1998

[55] Kingham S, Zant T and Johnston D (2004) The impact of the minimum driver licensing age on mobility in New Zealand. Journal of Transport Geography, 12: 301-314.

5.7.3. Low Income Households

Low income households across all ethnic groups will be vulnerable to the impacts of the screening programme. They are more likely to own older vehicles with higher emissions and are less likely to be able to afford repairs or replacement vehicles.

There is now an extensive New Zealand literature, both quantitative and qualitative, on both poverty and living standards. That literature identifies a range of ways in which those who are excluded or who are faced with dimensions of exclusion are limited in the extent of their participation in daily life in contemporary New Zealand society. Transport and access to transport are not directly included in most of that literature. However, its availability is, prima facie, crucial in determining the impact of the other dimensions of poverty and inadequate living standards. This is reflected, for example, in a number of the items in two of the four dimensions (economising items and social participation restrictions) of the Economic Living Standards Index scale developed for the household living standards study undertaken by the Ministry of Social Development[56, 57]. Those two dimensions of the scale include impacts such as[58, 59]:

- ability to visit doctors and dentists;
- putting up with being cold;
- inadequate or unhealthy food;
- wearing worn and inadequate clothing;
- having to cut down on visiting;
- inadequate or inappropriate housing, including sharing accommodation;
- letting accommodation run down;
- not joining in recreational and cultural activities;
- not providing children with the educational and recreational opportunities which their levels of development and the lives of their peers require[60].

Self reported and descriptive surveys have indicated financial difficulties and poor health, education and dietary outcomes particularly for solo parents, large families, disabled, the elderly, Maori and Pacific Islanders[61].

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[56] Krishnan, V., Jensen, J., Ballantyne, S. (2002) *New Zealand Living Standards 2000*. Wellington, Ministry of Social Development

[57] The ELSI scale has four dimensions – economising, ownership restrictions, social participation restrictions and self-assessment of standard of living. Within each of these dimensions, there are a series of specific components which are used to build the assessment of the standard of living. The final scale is a standard of living that ranges between 'very restricted standard of living' at one end of the seven point continuum and 'very good standard of living' at the other end of the continuum.

[58] Stephens R (2000) Poverty in Aotearoa/New Zealand: the social impact of reform. Social Policy and Administration 34: 64-86 (Stephens R personal communication)

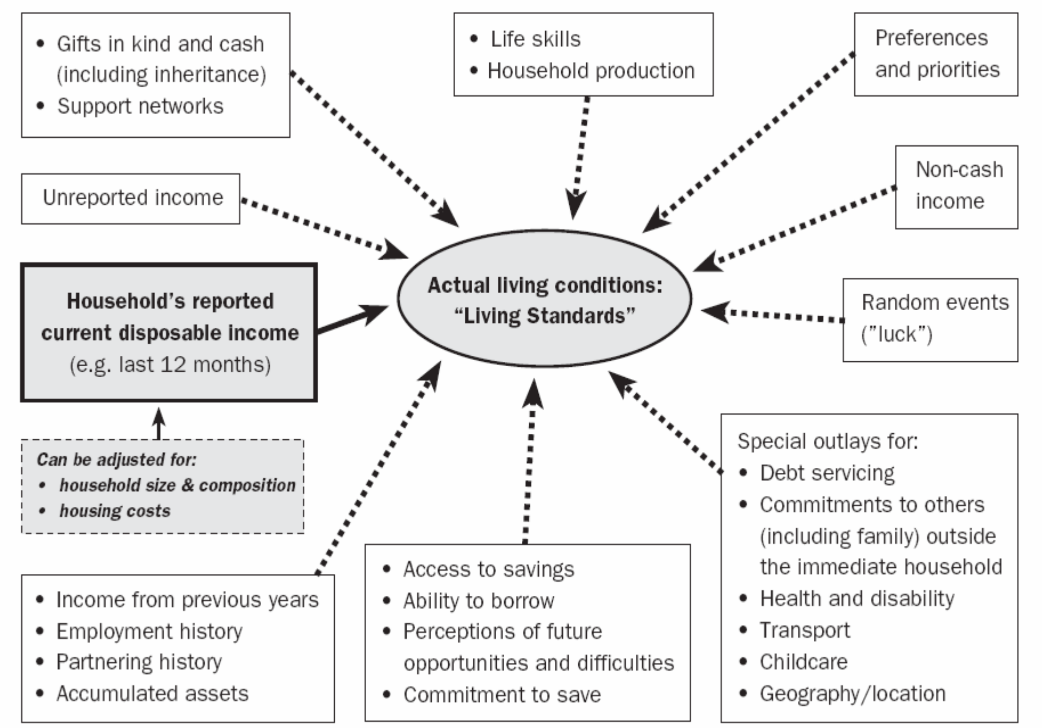
[59] O'Brien M (2000) Perpetuating poverty – what stops progress?. School of Social Policy and Social Work. Massey University. DevNet Conference 2000.

[60] Stephens R (2000) Poverty in Aotearoa/New Zealand: the social impact of reform. Social Policy and Administration 34: 64-86 (Stephens R personal communication)

[61] Easton 1986 and Waldegrave et al 1997 in Stephens R (op cit).

In terms of identifying vulnerable groups, Perry[62] reports on the mismatch between income-based measures of poverty and actual living conditions as a measure of poverty (Figure 49). His analysis suggests that an understanding of some of these other factors is important in understanding exactly how the impacts of a substantial bill will be felt. Some of these factors, eg support networks, are also important in understanding the effects of a loss of vehicle. These issues will be explored in more detail through the focus groups analysis in Phase II of this project.

Figure 49 Income and Other Factors that Affect Living Conditions



Source: Perry B (2002) The mismatch between income measures and direct outcome measures of poverty. Social Policy Journal of New Zealand, 19: 101-127

Transport is critical in determining the effect and impact on individuals, families and households and on the extent to which each or any of these dimensions increase the extent of social exclusion. While individual car ownership is not a necessary prerequisite for mitigating or eliminating the social exclusion dimensions of these components, lack of a private motor vehicle will certainly heighten their effect and meaning, and hence will strengthen the sense and severity of social exclusion.

Lucas and Grosvenor *et al* note that low income groups often act as informal community transport providers for friends, family and neighbours. Thus, when a low-income family loses a car for whatever reason, the impacts extend beyond the basic household unit. This suggests that loss of a car in low-income families is more serious than for higher

[62] Perry B (2002) The mismatch between income measures and direct outcome measures of poverty. Social Policy Journal of New Zealand, 19: 101-127

income families that do not participate in such transport arrangements.[63] The positive side of these arrangements is that it may enable individual households to be better supported by a wider community.

Issues to be addressed in focus groups would include:

- confirmation of the output of elasticity research on likely impacts of large bills on expenditure;
- the kinds of trips that would be displaced by loss of vehicle;
- the extent of formal and informal social arrangements that would limit impacts of loss of vehicle.

5.7.4. Maori and Pacific Peoples

The vulnerability of Maori and Pacific Peoples is related to their relatively low incomes, as discussed above. Vulnerability will be greater for Maori because of their higher vehicle dependency—similar to Europeans.

For Pacific peoples, impacts may be related to larger family sizes and thus the wider impacts of any loss of vehicle. However, this might be balanced by the existence of wider community support networks.

Issues to be addressed in focus groups will be similar to those for low income households.

5.7.5. Solo Parents and Large families

Solo parents and large families are vulnerable because of their low disposable income and the same issues apply. Solo parents can have unique problems relating to time scheduling that mean loss of vehicle particularly affects their level of social inclusion.

For large families the impacts of a loss of vehicle can be felt widely because of the number of people affected.

Issues to be addressed in focus groups will include:

- confirmation of the output of elasticity research on likely impacts of large bills on expenditure;
- the kinds of trips that would be displaced by loss of vehicle;
- the extent of formal and informal social arrangements that would limit impacts of loss of vehicle;
- the range of people affected.

5.7.6. Disabled

One group missing from our classification above is people with disabilities. While there has been no recent work specifically focusing on living standards among people with disabilities, there is a solid body of international evidence which clearly demonstrates

[63] Lucas, Grosvenor and Simpson "Transport, the environment and social exclusion". Available on the web at: http://www.jrf.org.uk/bookshop/eBooks/1859352936.pdf

that this group is over represented among those in poverty and those at risk of exclusion[64]. The limited New Zealand literature also identifies a range of costs associated with disability, including transport costs, and supports the international literature in suggesting that those with disability are at greater risk of social exclusion than their able-bodied fellow citizens.[65]

There is inadequate research data available on the income position of people with a disability to enable any comments, based on existing data, to be made about their potential vulnerability. However, the limited existing data, the international evidence and the experience of those working with disabled people all suggest that the effects on this population warrant examination.

UK studies have highlighted the difficulties that disabled people have in accessing public transport as a key component of wider social exclusion[66]. It reduces the options available to them in instances when there is a loss of vehicle. In the UK, disabled people travel a third less often than the general public[67] and over a third of those who do travel experience difficulties, the most common being getting on or off public transport.

Issues to be addressed in focus groups will include:

- Understanding vehicle dependence;
- likely impacts of large bills on expenditure;
- the kinds of trips that would be displaced by loss of vehicle;
- the extent of formal and informal social arrangements that would limit impacts of loss of vehicle.

5.8. Conclusions

Those most at vulnerable to the adverse impacts of the programme are:

- low income households—most likely to own a failing vehicle and least able to pay for the repairs; and
- those who rely on vehicles for their ongoing participation in work and other activities.

The analysis suggests that the communities at greatest risk from the proposed screening programme include young and old people, particularly Maori and Pacific Islanders, solo-parents, large families and disabled people.

The impacts of having to pay a significant bill for low income households can be estimated from existing studies; they will be explored in more depth in the next phase of

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[64] Oliver, M. (1996) *Understanding Disability: From Theory to Practice*. Basingstoke, Macmillan

[65] Curtis, E. (1986a) (2nd ed.) *Income of persons with disabilities*. *Vol. 1.* Wellington, Disabled Persons Assembly. Curtis, E. (1986b) *The extra costs of disability : A Report*. Palmerston North, Disabled Persons Assembly. (With The Disabled Persons Assembly).

[66] Prime Minister's Strategy Unit (2005) Improving the Life Chances of Disabled People. UK Cabinet Office.

[67] Disabled Persons' Transport Advisory Committee (2002) *Attitudes of disabled people towards public* transport, DPTAC. In: Prime Minister's Strategy Unit (op cit)

this project. The impacts result from reductions in spending on other items or descending further into a spiral of debt. Studies on poverty in New Zealand have identified a range of implications for low income households including increased probability of eating poorly, not going to the doctor or dentist, reducing participation in recreational activities, reduced educational opportunities for children and living in unsuitable accommodation.

Loss of a car can exclude households from many activities, including health visits, work, shopping, visiting friends and recreation. The difficulties relate particularly to centralised as opposed to distributed facilities. These include hospitals, educational facilities and supermarkets. Some of these issues are compounding problems for low income households:

- avoiding visiting doctors and dentists because of their costs is compounded by travel difficulties;
- reductions in transport options reduce employment opportunities;
- reduced access to supermarkets will often limit access to lower-priced and/or better quality food.

While the research suggests that alternative arrangements might be made for some of these trips, and particularly those regarded as essential. The lower marginal value (discretionary) trips for the individual may also be those that add variety, interest and pleasure to life.

6. Policy Options

In this section we identify possible response measures to the social impacts discussed in Section 5. This is not a comprehensive review or detailed analysis at this stage. Rather it identifies broad classes of instrument that might be examined in detail in Phase II of the study. It does this on the basis of a review of measures taken internationally to address the socio-economic impacts of emissions testing programmes, measures used to address problems of social exclusion and from first principles. The discussion includes policy instruments that aim to limit the:

- total costs of the programme, eg through integrating emissions testing with economic instruments;
- initial effects, particularly on vulnerable groups, eg targeted waiver programmes;
- vulnerabilities, such as through addressing vehicle dependency, social exclusion and income.

We firstly describe experience in other countries, focusing on programmes set up to address vehicle emissions testing programmes and social exclusion. We next examine possible options for New Zealand.

6.1. US Waiver Programmes

In the US, waiver programmes have been introduced to limit the impacts of the vehicle emissions inspection and maintenance programmes. These include:

- repair waiver programmes that ensure there is a cap on the total repair expenditure for individual vehicles;
- hardship programmes that limit expenditures for low income households;
- age–related waiver programmes; and
- low-use waiver programmes that limit requirements for vehicles that are little used.

6.1.1. Repair Waiver Programmes

Repair waiver programmes are used by many States. They are established either as a:

- maximum expenditure, ie no-one needs to spend more than the maximum amount on a vehicle. These provide certainty on the maximum expenditure; and
- minimum expenditure, i.e. to obtain a waiver a vehicle owner needs to have spent at least the minimum. This provides less certainty that a waiver will be obtained.

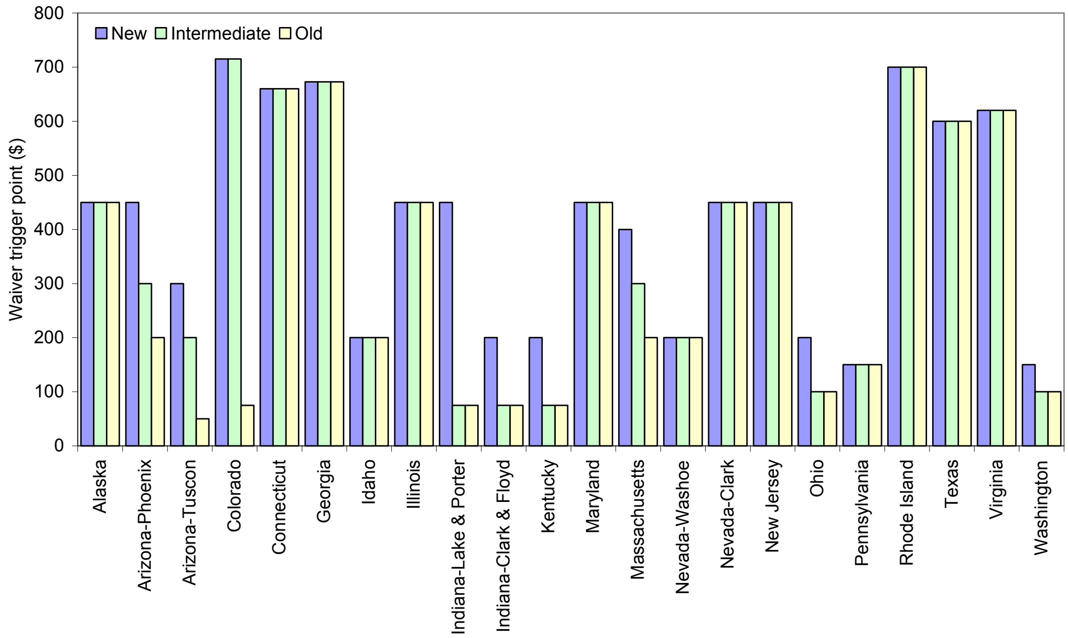
In principle these mechanisms have the same effect. The maximum or minimum is the repair spend, above which vehicle owners are eligible for a waiver. Generally the waiver allows the vehicle to be used for another year. Vehicle owners must demonstrate that a certain amount has been spent. There will often be restrictions to this, eg:

- emission control devices are working;
- there is no visible smoke; and

- there is an improvement in emissions, even if not sufficient to meet the standard expected.

The level employed varies widely by State. Figure 50 illustrates. Some States vary the threshold used with the age of the vehicle; Figure 50 includes the thresholds for new and old vehicles and those of intermediate age. These classifications vary somewhat by State also…

Figure 50 Repair Spend Thresholds for Repair Waivers



6.1.2. Hardship Waivers and Assistance Programmes

Some States have introduced programmes which either provide repair assistance, or exempt or reduce the requirements for low-income households.

California has a Consumer Assistance Program that makes funds available to assist low income households to pay for emissions-related repairs. Motorists whose household income is at or below 185% of the federal poverty guidelines (Table 15) qualify for repair assistance of up to US$500. For example, a family of four whose income does not exceed US$34,873 per annum is eligible. Qualified consumers must pay the first $20 towards diagnosis or repair. Texas has a similar programme of repair cost assistance to low income families— AirCheck Texas Repair & Replacement Assistance Program; it provides US$30-600 per vehicle for eligible motorists[68].

In Oregon a pilot programme (Clean Air Partners) has linked the Department of Environmental Quality with a charitable foundation[69] to build a fund through voluntary

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[68] http://www.tnrcc.state.tx.us/air/ms/vim.html

[69] the United Way of the Columbia-Willamette and Ron Tonkin Family of Dealerships

public donations[70]. The fund is used to assist low-income households to pay for vehicle repairs; those who qualify pay only $50 of the repairs.

Table 15 US Federal Poverty Guidelines

Size of Family Unit	48 Contiguous States and D.C.	Alaska	Hawaii
1	$ 9,310	$11,630	$10,700
2	12,490	15,610	14,360
3	15,670	19,590	18,020
4	18,850	23,570	21,680
5	22,030	27,550	25,340
6	25,210	31,530	29,000
7	28,390	35,510	32,660
8	31,570	39,490	36,320
For each additional person, add	3,180	3,980	3,660

Source: http://aspe.hhs.gov/poverty/04poverty.shtml

In Illinois, those meeting income criteria can have a temporary (less than 12 month) extension of time in which to repair their vehicle if they meet income criteria and have a written estimate for repairs totalling at least US$225 for repairs or parts[71]. In Ohio, the possible extension is for 6 months and the required estimate for repairs is US$75.

6.1.3. Accelerated Vehicle Replacement

In Texas, in addition to repair assistance, there is an accelerated vehicle replacement programme for low income households. It provides US$600-1,000 towards a replacement vehicle where the vehicle owner's net family income is at or below 200% of federal poverty rate (see Table 15).

6.1.4. Time Related Waivers

In Alaska, there is a seasonal waiver— owners of vehicles operated only from April 1 to October 31, when Anchorage has not historically exceeded the federal standard for CO, may be eligible for a waiver from emissions testing requirements; driving vehicles with a seasonal waiver is prohibited between November 1 and March 31[72]

Alaska also has a waiver condition for failing a test when the faulty component is documented to be on order; the owner can extend the period of time in which the repairs must be completed.

6.1.5. Age related Waivers

In Georgia there is a Senior Waiver available for vehicle owners that are 65 years or older and drive less than 5,000 miles per annum[73].

[70] www.deq.state.or.us/aq/vip/ifyoufail.htm
[71] Illinois Environmental Protection Agency (2004) A Guide to the Illinois Vehicle Emissions Inspection Program.
[72] www.ci.anchorage.ak.us/healthesd/vehicle.cfm#Repair
[73] www.cleanairforce.com/waivers_etc/

6.2. Vehicle Dependency/Social Exclusion

There is a wide range of measures that, in combination, address issues related to the disconnection of people from their communities and the centrality of transport issues within this. The terminology is different but there are similarities in programmes in different countries. In the US, these issues are addressed through Smart Growth initiatives; in the UK the issue of social exclusion is the focus for policy activity.

These programmes are of interest in this context because they address the vulnerability of communities, and household and individuals within them, to crises such as losing a vehicle and even to debt. They are examples of government programmes aiming to (re)build a sense of community and neighbourhood.

Smart Growth is the description for a range of initiatives in the US aimed at encouraging:

- more compact cities;
- more use of public transport; and
- a greater sense of community.

These are integrated programmes with multiple objectives, but the underlying philosophy is one in which, via the increased interaction of people and the building of a better sense of community, people are more resilient to crises, they make choices which take more account of the external effects and there are benefits for the environment and the economy.

The UK Social Exclusion Unit has identified a number of measures related to social exclusion because of lack of access to transport. These include measures that[74]:

- improve physical accessibility and availability of public transport;
- make travel more affordable, eg concessionary fares, travel vouchers, public transport subsidies;
- provide better information on travel options;
- reduce the need to travel through land use planning, encouraging delivery of goods and services; and
- improve safety of streets and public transport.

These measures are all consistent with the objectives of the New Zealand Transport Strategy and other integrated government programmes such as the Sustainable Development Programme of Action[75]. They are long term measures that may reduce private vehicle dependency and the impacts of emissions screening programmes. However, we assume that they are part of the policy environment in which the emissions screening programme is introduced. The focus of our analysis of policy

[74] Social Exclusion Unit (2003) Making the Connections: Final Report on Transport and Social Exclusion. Office of the Deputy Prime Minister

[75] Sustainable Development for New Zealand. Programme of Action. January 2003. Department of Prime Minister and Cabinet.

options is thus on measures that more directly tackle the expected impacts of the emissions screening programme.

6.3. Options for New Zealand

Phase II of this study will include consideration of a wide range of policy options to mitigate the impacts of the programme. Here we briefly discuss measures that:

- limit the costs of the programme;
- address the effects.

6.3.1. Limiting Total Costs

Emissions testing programmes have traditionally been introduced as emission standards. Requiring all vehicles that fail to meet the standard either to undertake repairs or to scrap the vehicle, takes no account of levels of use of the vehicle and its actual environmental impact. Alternative approaches might use the data from the emissions test as input to an emissions charge. We understand that MoT has expressed an interest in the use of economic instruments alongside an emissions test.

As an example of the approach, measured emissions times the change in the odometer reading might be used to estimate total annual emissions as a basis for a charge. Vehicle owners could avoid the charge through undertaking repairs or maintaining/tuning the vehicle prior to the test. This is likely to provide incentives for low use vehicles to pay a charge while high use vehicles undertook the repairs. Pre-test maintenance measures might be rewarded more than post-test repairs.

The same approach could be used to develop an emissions allowance trading scheme. For example, vehicles might be initially endowed with allowances to emit certain quantities of pollutants. Emissions testing would reveal the total amount emitted and thus either the capacity to sell spare allowances or the requirement to purchase additional allowances. In a similar way to the emissions charge, repairs and maintenance can be used to reduce the requirement for allowances.

There are a number of issues that are crucial to analysis of such instruments:

- the incentives for avoidance, such as through altering odometer readings;
- the equity implications of widening the incidence of costs. Whereas an emission standard might concentrate impacts on low income households, it is still limited to those households that failed the test, a charge would increase costs for all households, particularly low-income households;
- the level of transaction costs, particularly associated with tradable allowance schemes;
- issues of fairness in tradable allowance schemes—surplus allowances for low emitting vehicles and requiring allowance purchases of high emitters may lead to the poor subsidising the rich.

6.3.2. Limiting the Size of the Initial Effect

The US waiver programmes provide a wide range of examples of instruments that can be used to limit the effect. They seek to isolate either vehicles on which a lot has been spent and to cap the ongoing expenditure, or to target particular household types for relief so that the total costs can be limited. Other programmes provide repair assistance or financial incentives for early vehicle scrapping.

Our analysis of these approaches will be expanded in the next phase of this project. A number of issues can be raised at this stage which will be explored later.

- there are boundary issues associated with any use of a threshold particularly for targeted assistance, eg households that meet income criteria, ie the differentiated treatment of households that fall just above and just below the intervention threshold;
- hardship or vulnerability is difficult to measure for policy purposes. those available—income, household size etc—do not take account of many other issues that contribute to actual hardship;
- there may be potential perverse incentives for vehicle ownership to be vested in poorer households, eg families to use their poor friends and relations;
- there is the potential for inflating the costs of repair, particularly for subsidised programme;

These and other issues that influence the effectiveness of the programme in achieving its core social objectives will be addressed in the next phase.

6.3.3. Addressing Vulnerabilities

Measures that address the vulnerabilities of households include instruments that are part of other policy programmes. These include measures aimed at addressing:

- low income;
- access to and demand for public transport.

As noted above, while these wider programmes will have an impact on the effects of the emissions screening programme, we do not intend to analyse them in detail. In essence, they are part of the counter-factual in analysis—we expect them to happen anyway. It is unlikely, given the core objectives of these policies, that the impacts of the emissions screening programme will alter their design or implementation.

6.3.4. Programme Design Issues

There are a number of design issues of the programme itself which will be subject to additional consideration in terms of their social impacts. These include:

- The separation or integration of the emissions test and the WoF;
- The type of network—centralised, decentralised or hybrid;
- Targeting of the programme, including the vehicle coverage—eg the trade-off between the reduced social impacts of excluding older vehicles and the environmental impacts of doing so.

7. Conclusions

This initial review of the proposed emissions screening programme has identified a number of potential social impacts of the scheme and provides direction for analysis in Phase II of the study.

7.1. Social Impacts

The analysis at this stage has used vehicle age as an initial way of identifying who might be affected by the screening programme. There is a clear link between vehicle age and income in a way that suggests low income households will be most affected. There are also regional differences in the vehicle fleet, with older vehicles more common outside of the main centres and in the South Island.

Failing a test results in either a potentially large bill or a decision to scrap a vehicle. The latter decision leads either to a significant bill for obtaining a replacement vehicle or to living without one. Those most vulnerable to the impacts of the screening programme are those households or groups that have low incomes and are highly vehicle dependent.

The analysis suggests that the communities at greatest risk from the proposed screening programme are young and old people, particularly Maori and Pacific Islanders, and solo-parents.

The impacts on these vulnerable groups if a vehicle fails include:

- The impacts of having to pay a significant bill—for low income households these include reductions in spending on other items or descending further into a spiral of debt. There is increased probability of eating poorly, not going to the doctor or dentist, reducing participation in recreational activities, reduced educational opportunities for children and living in unsuitable accommodation.

- The impacts of not having a car—these include reductions in trips that compound some of the problems of low income: because of the difficulties of access—reduced visits to doctors and dentists, difficulties in getting to work and reduced employment opportunities, harder to get to supermarkets. People will also cut down on the more discretionary trips that, for many, provide variety and interest to life.

7.2. Work in Phase II

The work in Phase II will expand on some of the issues included in this initial work and develop new lines of analysis. The key components are discussed below.

7.2.1. Vehicle Segmentation

The vehicle fleet will be segmented or categorised to group vehicles with similar emission characteristics. This will be undertaken in association with MoT and the pilot programme team. It is likely to be based around the following parameters:

- vehicle age;
- fuel; and
- engine size.

This segmentation is required for our analysis of the vehicle fleet.

Scenarios for an emissions rule will be used that enables us to identify which vehicles are most likely to fail the requirements of the rule.

7.2.2. Analysis of the Vehicle Fleet

We will categorise the vehicle fleet in the LTNZ database using the above categories. We will then associate the vehicles with the meshblock of the owner and use the emission categorisation and probability of failure to identify the proportion of vehicle failures per meshblock.

7.2.3. Association of Socio-Economic Data to Meshblocks

We will bring together socio-economic data from the census at the meshblock level in a way that allows us to associate the risk of failure and the expected primary effects of failure (repair bills, loss of vehicle) with the characteristics of the households in the meshblock. This allows us to test some of the initial conclusions from this work, eg on the relationship between risk of failure and low income.

7.2.4. Focus Group Analysis

Focus Groups will be used to explore the impacts in more detail to get beyond the primary measures of effects.

7.2.5. Policy Analysis

A range of different instruments will be analysed, as discussed in Section 6. The analysis will include an evaluation of the effects on:

- the socio-economic impacts of the programme;
- the environmental effectiveness; and
- the costs and other distortions of the instruments.

Annex 1—US Emission Tests

Tests

Inspection and maintenance (I/M) programmes for in-use vehicles are prescribed under the Clean Air Act Amendments of 1990 for specific geographical locations, depending on levels of non-attainment with National Ambient Air Quality Standards (NAAQS).

History

This section describes the historical development of inspection and maintenance (I/M) programmes in the US. The description is taken largely from a recent US EPA guidance document[76].

The 1970 Clean Air Act included I/M as a non-mandatory option for improving air quality; the first programme was introduced in New Jersey in 1974, consisting of an annual idle test for 1968 and newer vehicles (gasoline-powered passenger cars).

I/M became mandatory for geographic areas with long term air quality problems in the Clean Air Act Amendments of 1977; they were to be part of State Implementation Plans (SIPs) for areas in non-attainment with national ambient air quality standards (NAAQS). However, the USEPA had little legal authority to enforce minimum requirements and there was considerable state-to-state inconsistency.

The 1990 Clean Air Act Amendments (CAAA) were much more prescriptive, while also expanding I/M's role as an attainment strategy. The CAAA required EPA to develop Federally enforceable guidance for two levels of I/M programme:

- "basic" I/M for areas in moderate non-attainment of NAAQS; and
- "enhanced " I/M for serious and worse non-attainment areas, as well as for areas within an Ozone Transport Region (OTR)[77], regardless of attainment status.

The guidance was to include minimum performance standards for I/M programmes and implementation issues such as network design, test procedures, oversight and enforcement requirements, waivers and funding. The CAAA also mandated that enhanced I/M programmes were to be:

- **annual**, unless biennial was proven to be equally effective;
- **centralised** (consisting of a relatively small number of stations that perform emission tests only[78]), unless decentralised (a larger number of stations that do both emissions testing and vehicle repairs) was shown to be equally effective; and

[76] US Environmental Protection Agency (2004) Guidance on Use of Remote Sensing for Evaluation of I/M Program Performance. EPA420-B-04-010

[77] The concept of an OTR was introduced because some States could not achieve ambient standards because of movement of pollutants from other states. Some areas upwind on non-attainment areas are defined as part of an Ozone Transport Region.

[78] Committee on Vehicle Emission Inspection and Maintenance Programs Toxicology (2001) Evaluating Vehicle Emissions Inspection and Maintenance Programs

- **enforced through registration denial,** unless a pre-existing enforcement mechanism was shown to be more effective.

The USEPA published an I/M rule in 1992 which established the minimum procedural and administrative requirements to be met by basic and enhanced I/M programs. It also included a performance standard for basic I/M based upon the original New Jersey I/M program and a separate performance standard for enhanced I/M, based on the following program elements (the test methods are described in Box 1):

- Centralised, annual testing of model year (MY) 1968 and newer light-duty vehicles (LDVs = passenger cars) and light-duty trucks (LDTs) rated up to 8,500 pounds GVWR;
- Tailpipe test:
  - MY1968-1980 - idle;
  - MY1981-1985 - two-speed idle;
  - MY1986 and newer - IM240.
- Evaporative system test:
  - MY1983 and newer - pressure;
  - MY1986 and newer - purge test.
- Visual inspection: MY1984 and newer - catalyst and fuel inlet restrictor.

The emission tests are explained in Boxes A1 and A2.

Box A1 Tailpipe Emissions Tests

Mass Emissions vs Concentration Measurements

Mass emission tests quantify vehicle exhaust emissions by measuring the mass of pollutants emitted; generally emissions are expressed as the mass of pollutant emitted divided by the distance travelled in a simulated driving cycle. Typically a vehicle is driven on a dynamometer (a set of rollers on which a test vehicle's tyres rest) for the test.

Concentration tests measure the relative concentration of pollutants in a vehicle's exhaust, without measuring the absolute amount of pollution. For a given exhaust concentration, vehicles with larger engines will have larger mass emissions. To understand mass emissions, exhaust volume can be measured also. Exhaust volume is measured in some emission tests.

Steady-State versus Transient Testing

Steady-state tests measure vehicle emissions under one stable operating condition. This includes tests without a dynamometer, in which vehicles are typically tested at idle, or using a dynamometer when tests are at a steady speed. Steady-state tests are quicker to undertake and are lower cost.

Transient tests require a vehicle to operate under varying speeds and loads. They are much better at representing on-road driving conditions.

Mass Emissions Tests

- **Federal Test Procedure (FTP)—City Driving Test**
  This is usually considered the benchmark emissions test against which others are measured. The test is split into different phases to measure emissions from cold-start, urban driving and hot-start operating conditions. It usually takes 2 days per vehicle and costs approximately $2,000[79]. The figure below outlines the components.
- **Supplemental Federal Test Procedure (SFTP)**
  A modified form of the FTP to take account of aggressive acceleration and driving with air conditioning.
- **IM-240**
  This is a shortened version of the FTP in which the vehicle is given minimal conditioning and is

[79] Illinois Environmental Protection Agency (2004) A Guide to the Illinois Vehicle Emissions Inspection Program.

assumed to be fully warm. It is a transient dynamometer test which collects emissions over a 240-second, 2-mile driving cycle that corresponds to the first 240-seconds of the City Driving Test of the FTP.

- **BAR31**
  Similar to the IM-240 but shortened to 31 seconds, with the vehicle sharply accelerating and then decelerating. A vehicle has three chances to pass.
- **IM93/CT93** (Connecticut 93)
  A shortened version of IM-240 using the first 93 seconds.
- **IM147**
  A shortened version of the IM-240 using the final 147 seconds. There is a retest algorithm that determines whether a failing vehicle needs preconditioning before a final failure determination.
- **VMASS**
  The VMASS flowmeter converts a concentration measurement to mass measurement. The test methodology can use any transient I/M test cycle (eg BAR31, CT93, IM147).

Concentration Tests

- **Idle Tests**
  This is a steady-state test in which a tailpipe probe is used to measure pollutant concentrations in exhaust emissions from idle vehicles. No load is applied to the engine. Idle tests include
  - Low-idle or natural tests; and
  - High-idle tests in which engine speed is manually increased to c.2,500 rpm.

  NOx emissions are not usually measured because NOx emission are low if the engine is not under load. The idle test is less expensive than loaded-mode tests because no dynamometer is required. Concentration measurements can be converted to mass.
- **Acceleration Simulation Mode (ASM)**
  A series of loaded-mode steady-state emission tests that measure exhaust concentrations from vehicles on a dynamometer. The tests use the maximum acceleration events in the FTP.
- **BAR97**
  This refers to emission equipment and software that meet the California Bureau of Automotive Repair's specifications. The equipment can be used with an idle or ASM test, and can be used with a VMASS flow meter to measure mass emissions.
- **Remote Sensing**
  A method for measuring emission from vehicles as they drive by. A beam of light is projected across a traffic lane at tailpipe height. The light absorbed by pollutants is measured. Typically remote-sensing measurements are coupled to video images of the license plate.

On-Board Diagnostics (OBD)

The OBD system is a computerised system that both monitors the vehicle's performance and alters the vehicle's functioning. With a few exceptions all passenger cars built after 1996 have an OBD system. The OBDII system checks catalysts, oxygen sensors, evaporative canister purge systems, fuel tank leaks, misfiring and on-board computers. A light appears on the dashboard if a problem is detected that could cause emissions to exceed 1.5 times the emissions standard.

Source: Committee on Vehicle Emission Inspection and Maintenance Programs Toxicology (2001) Evaluating Vehicle Emissions Inspection and Maintenance Programs; http://www.dieselnet.com/standards/cycles/ftp75.html

Box A2: Evaporative Emission Tests

Evaporative emissions can occur from various places on the vehicle, including fuel tank, filler neck, petrol cap and engine. To measure all of these potential leaks requires that the whole vehicle is enclosed. A partial solution is targeted inspection, eg the petrol cap is screwed onto a test cavity and put under pressure. The fuel-tank vapour system can also be pressure-checked.

A purge check is also undertaken. Activated carbon in a canister stores the fuel tank hydrocarbon vapours. The engine's vacuum is used to draw air through the carbon bed.

Source: Committee on Vehicle Emission Inspection and Maintenance Programs Toxicology (2001) Evaluating Vehicle Emissions Inspection and Maintenance Programs

In early 1995, the ASM test was deemed an acceptable alternative to IM240 and the use of decentralized I/M programmes was approved, although states needed to show that the results were as good.

In 1996 On-Board Diagnostic checks were introduced as a required component of the regular I/M test procedures. OBD checks, exhaust tests and evaporative system tests, where applicable, were to be required on each subject vehicle of model year 1996 and newer.