Effects of Changes to Periodic Inspection Policy on the Roadworthiness of ACT Vehicles

Feasibility Study

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for

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Introduction

This report sets out the results of a study to determine whether suitable data exists to support an evaluation of the effects of changes to vehicle inspection policies on the roadworthiness of motor vehicles in the Australian Capital Territory (ACT). Possible effects on road accident statistics were also of interest.

Background

For several decades ACT motor vehicles underwent annual roadworthiness inspections. Beginning in 1980 the ACT government progressively phased out annual roadworthiness inspections for most types of vehicles. In 1991 only light vehicles older than 6 years required an annual inspection. In 1993 about 5% of light vehicles between 3 and 10 years of age were randomly selected for an annual inspection and all light vehicles over ten years old were selected. By 1994 only light vehicles over 10 years old required an annual inspection (this still covered nearly half of the vehicle fleet) but an informal system of "exemptions" was introduced, partly to reduce the length of queues. This involved an inspector checking vehicles in the queue and exempting some if there were no obvious defects. About half of the vehicles were exempted, meaning that about one quarter of all ACT light vehicles still underwent an annual inspection.

A targeted roadside inspection program began around 1992. "Random selection" roadside inspections were developed through 1993/94. It was not until December 1994 that records of these inspections were reliably available.

In the ACT buses and heavy trucks continue to undergo annual inspections and these might form a control group for any statistical analysis.

Related studies

Norway

A comprehensive study was undertaken by Stein Fosser (1992) in Norway in the late 1980's and covered about 200,000 cars over a three year period. About one quarter of the cars were inspected once, at the start of the three years, a further quarter were inspected each year and the remainder (half) were not inspected. No statistically significant difference in accident rates was found between the three groups. It should be noted, however, that Norway has a prominent random inspection program which covers about 15% of the fleet each year. Awareness of roadworthiness is probably high amongst Norwegian vehicle owners. The results therefore might not be applicable in the Australia.

USA

In 1989 the US National Highway Traffic Safety Administration published a report "Study of the Effectiveness of State Motor Vehicle Inspection Programs" (NHTSA 1989). The study found that "there was no conclusive evidence in the literature that periodic motor vehicle inspection programs are, or are not, effective in reducing crashes. This study was subsequently reviewed by the US General Office of Accounting (GOA 1990), which concluded that NHTSA should "resume its support of State periodic inspection programs".

The NHTSA study included a literature review of the effectiveness of inspections in improving vehicle condition. The study found that there was a wide range in the quality of

various state programs and that the better quality programs lead to better-maintained vehicles. Detailed results were:

Table 1

Effect of Periodic Inspections on Vehicle Condition

Study	Location	Type of Inspections	% Defective
McCutcheon & Sherman 1968	Washington DC	Annual	42.6%
	Cincinnati	Semi-annual	34.1%
	Memphis	Tri-annual (fewer categories)	12.4%
	Ann Arbor	None	93.7%
Fisher 1971	Pennsylvania	Semi-annual - private stations	5.93%
	Washington	Annual	7.44%
	New Jersey	Annual	8.93%
	California	Police roadside	10.7%
Innes & Eder, 1977	Alabama	None	93.2%
	Arizona	None	91.9%
	Tennessee	Annual	47.4%
	Washington DC	Annual	48.0%
	Puerto Rico	Annual (poor quality?)	90.4%
Fosser, Norway 1990 (*defects per vehicle)	Group 1	Annual	1.73*
	Group 2	Once (three years earlier)	2.23*
	Group 3	None	2.41*

Evidently the type of audit inspection conducted varied between each of these studies.

The NHTSA study also refers to a "before and after" study when annual inspections were discontinued in Idaho. "Brakes, steering, suspension and power train components were somewhat worse [after annual inspections ceased] while body components (lights etc) were about the same". For these tests a mobile inspection van was set up in a parking lot and vehicles were recruited on a "drop-in basis".

New South Wales

Heavy Vehicle Inspections

The NSW Roads and Traffic Authority recently released the results of its "Heavy and public passenger vehicle roadworthiness assessment program" (Taverner 1995). Heavy trucks and buses were randomly selected at numerous sites throughout NSW in 1992 and 1995. The aim of this program is "to audit the maintenance of vehicles and to ensure vehicles are in a fit and proper condition to use the road system". Factors such as vehicle age, type of vehicle, odometer readings, vehicle use and commodity carried, jurisdiction of registration and type of service were analysed. A total of 1939 were inspected in 1995, compared with 1885 in 1992. On average vehicles inspected in 1995, particularly buses, were in better condition than those in 1992. Differences between areas of the state were also noted.

Similar reports on heavy vehicle inspection results were produced on an annual basis by the RTA (and former Dept of Motor Transport) between 1982 and 1989, although the selection methods for roadside inspections were not necessarily random.

Inspections in Shopping Centre Car Parks

In 1994 the RTA conducted a pilot study on inspections of light vehicles at shopping centre car parks. Vehicle Design and Research P/L managed that project, which identified objective inspection items that could be used as a measure of roadworthiness (including the use of a portable roller brake tester). Vehicle owners were approached as they returned to their car and were told they could have an immediate inspection or arrange an inspection at a later date. About half agreed to an immediate inspection and a total of 118 inspections were conducted at four sites throughout NSW (51% of people approached). Most people reacted positively to the request to present their vehicle for inspection.

Of the inspected vehicles only six were issued with defect notices but most cases were treated as cautions. 54% of vehicles had a defect of some type and 14% had at least one serious defect. One third had at least one brake fault (most of these could only be readily detected with a roller brake tester) and 11% had tyre defects. Water-contamination of brake fluid was found to be a problem in one third of the 54 vehicles tested with a hygroscopic meter.

Although the results were informative they cannot be regarded as representative of the NSW light vehicle fleet due to both the "voluntary" method of selection and the likelihood that vehicles intercepted in a shopping centre car park during a weekday might not be representative of the remainder of the fleet. The method was found to be demanding on resources, in terms of total person-hours per vehicle inspected, although the average time per vehicle inspection was on target at 15 minutes.

Brakes on light vehicles

Vehicle Design and Research P/L also managed a pilot RTA study of the performance of brakes on light vehicles. This involved setting up portable roller brake testers at eight petrol service stations throughout Sydney and inviting owners who fuelled their vehicles to have a "three minute" brake test. A total of 538 vehicle were tested. 19% failed one or more of the performance criteria (compared with 32% in the shopping centre study) and 8% failed the service brake test (compared with 9% in the shopping centre study). It was concluded that the methodology (which only looked at brake performance) would form a convenient measure of roadworthiness programs.

Audits of Roadworthiness - Sampling Issues

Biased sampling

To be useful, any sample must be truly representative of the population of interest. Bias is easily introduced and is not always easily recognised. For example:

- Roadside inspection work can be far more effective (in terms of reducing the number of defective vehicles on the road) if it is targeted at vehicles which are more likely to be defective. However, such targeted jobs are unlikely to be useful for audit purposes. (In the case of the recent RTA heavy vehicle audit, consultants conducted the selections at each site to ensure they were random.)

- Geographic differences are likely to exist in the vehicle fleet (each of the RTA studies referred to above found geographic differences) so studies conducted in different areas might not be valid for detecting differences over time.
- Vehicles intercepted in shopping centre car parks, for example, might differ from those used for commuting every day.
- The time of day and day of the week can have an influence. (observed during the light vehicle brake study)

Confounding factors

In addition to sampling issues, studies which compare two or more sets of results may also be influenced by confounding factors. For example:

- For time-based studies the economic climate might affect a vehicle owner's willingness to maintain a vehicle in good condition (the case in harsh economic times is clear but good economic conditions might encourage more families to have an extra vehicle which is not always in the best of condition).
- Other programs and publicity, such as roadside inspections might change people's awareness of roadworthiness issues.
- Management/staff issues, such as performance measures based on number of defect notices issued, might affect the likelihood of defect notices being issued and the grade of these defect notices.
- The types of items being inspected, method of inspection, pass/fail criteria and recording systems might differ. Quantitative measurements are preferred to subjective assessments by inspectors.

Finally, certain inspection procedures, such as measurements of brake force, are subject to measurement error. This might place a limit on the reliability of an analysis involving small differences between populations.

These sampling issues can usually be addressed in the case of roadworthiness audits through careful study design. In the case of road accidents, however, the effects of roadworthiness issues are likely to be swamped by other factors. The Fosser study was one in which the methodology was able to address all foreseeable factors. Unfortunately, as indicated previously, the results of that study might not be applicable in Australia due to the prominent roadside inspection program in Norway. In other words the conclusion for the Fosser study might be better phrased "in a country with an effective roadside inspection program an annual inspection program has no significant influence on road accidents".

Statistical analysis

The usual method of comparing the results of two samples is to employ the null hypothesis that there is no statistically significant difference between the two populations and derive a "z score" for the comparison (Spiegel, 1980):

Let P_A be the observed proportion of defects a sample N_A from population A and

Let P_B be the observed proportion of defects a sample N_B from population B

then $\mathbf{z = (P_A - P_B)/SQRT(pq(1/N_A+1/N_B))}$ **..... (1)**

where $p = (P_A N_A + P_B N_B)/(N_A + N_B)$ and $q = 1-p$

This method applies where the proportions (such as the percent failing a test) are known. Similar methods for deriving a z score are available for comparing sample means.

Note that the more-complicated Chi-squared testing is usually carried out where there are more than two samples and/or outcomes. In the case of two samples and two outcomes (pass or fail), such as the current project, the z-score method is appropriate (in such cases the square of the z score is equal to Chi-squared).

Confidence levels

The confidence level is termed moderately significant at 95% ($z > 1.96$ or $z < -1.96$) and highly significant at 99% ($z > 2.58$ or $z < -2.58$). In other words, if an analysis produces a z score of 2.0 then the difference is considered to be statistically significant at the 95% confidence level, which is moderately significant: not more than one in twenty (5%) experiments could be expected to produce the observed difference due to chance rather than an actual difference between the populations sampled.

Sample sizes

The above statistical theory can be used to derive minimum optimum sample sizes for certain scenarios. A larger sample size improves confidence (in the absence of bias or confounding factors) but is obtained at the cost of more expensive surveys and analysis. For the present study, minimum sample sizes are derived solely for the purpose of determining whether meaningful analysis can be performed on available data.

The effect of equation (1) is that, as the size of one of the samples reduces, the size of the other sample must increase by a disproportionate amount in order to retain the same level of confidence (i.e. z score). For a given level of confidence the overall number of tests is minimised (i.e. optimum) if the sample sizes are approximately equal.

Figure 1 shows the effect of the observed difference between two samples *of similar size* for several scenarios (P_1 = 5% to P_1 = 20%). Obviously the smaller the difference the larger the sample size required to achieve 95% confidence. Once the difference is less than 3% (absolute) the required sample size tends to increase in an exponential fashion. This, combined with the bias and confounding factors which are inevitable in roadworthiness surveys, makes analysis of differences of less than 3% unworkable.

Figure 1 - Optimum sample size for various scenarios

P1 is the proportion of sample 1 that are defective. P2 is the proportion of sample 2 that are defective.

Available data on the roadworthiness of ACT vehicles

Period of interest

The period of interest is from about 1980 to 1996. Over this period annual inspections of cars progressively reduced from all vehicles to none:

Year	Cars subject to annual inspection	Estimated proportion of fleet
Prior to 1980	All	100%
81-89	1, 3, 5 years and more	90%
90-93	6 yrs or more	70%
93-94	10 yrs or more, plus 5% of vehicles over 3 years.	55%
94-95	10 yrs or more but half of these exempted while queuing	25%
96	None	0%

During the period 93/94 roadside inspections were introduced. This is likely to be a confounding factor in any analysis of the effects of changes to annual inspections.

Problem statement

The following questions are relevant:

1. Did the roadworthiness of the total light vehicle population change over this period?
2. Did the roadworthiness of individual groups of vehicles (e.g. vehicles over 10 years of age) change over this period?
3. If a significant difference in roadworthiness can be detected, did the accident rates for the total light vehicle population change over this period?
4. If a significant difference in roadworthiness can be detected, did the accident rates for the individual groups of vehicles change over this period?

Measurement of roadworthiness

There are numerous ways of "measuring" roadworthiness:

- The RTA audit used the number of minor and serious defect notices actually issued by teams of inspectors. As a precaution a specialist team went through the forms and graded each defect according to a standard system ("NRTC" - actually developed by Vehicle Design and Research P/L under contract to the National Road Transport Commission). These reassessments were reported separately and there was relatively little difference between the two methods.
- The RTA shopping centre car park surveys evaluated several methods, including the recording key measurements, such as brake forces and wheel loads, tyre tread depth and steering wheel rotational free-play. Analysis of these measurements gave objective results but the sampling method had pitfalls. Also it was found that the number of defect notices issued did not give a good indication of the technical condition of the vehicle. Tyre condition did not appear to correlate with other faults (i.e checks of tyres alone would not be a reliable indicator of vehicle roadworthiness).
- Fosser reported on the number of defects per vehicle. This is unlikely to give a reliable indication of the seriousness of the defects.

ACT inspection data

The results of random-selection roadside inspections would give a reasonable "snapshot" of the roadworthiness of the ACT light vehicle population. Unfortunately for the purposes of the current project, there were no rigorous procedures to ensure that such selections were random for the roadside inspections conducted in the ACT over the period of interest (this is not intended as a criticism - targeted inspection are a more effective use of resources). This will affect the reliability of the data.

Bearing this precaution in mind, statistics on roadside inspections are only available from December 1994 onwards. These are in the form of summary statistics: date range; inspection site; type of selection (e.g. in connection with Police random breath testing or speed enforcement etc); number of vehicles inspected; number of vehicles issued with a minor defect notice; number of vehicles issued with a major defect notice and number of

vehicles issued with a caution. Results of individual inspections are not available which means that statistical tests to determine whether the samples are representative of the overall population in terms of age, make etc or whether certain groups were worse than others, cannot be performed.

Analysis of available data

Although the purpose of the current project was to determine whether suitable data was available, it transpired that the summary statistics were so few that a preliminary analysis was undertaken, with the help of Mr Rod Paule from the ACT Department of Urban Services. It is not appropriate that the detailed results of the roadside inspections be published in this report but the analysis found the following:

- Over the period December 1994 to December 1996 a total of 12 roadside inspection sessions involved relatively random selections. Just over 6,700 vehicles were inspected during these 12 sessions. This was roughly half of all roadside inspections conducted over this period.
- For analysis the sessions were split into 3 periods: 12/94-6/95, 7/95-12/95 and 1/96-12/96. Resulting sample sizes were approximately equal (between 1900 and 2400).
- Minor defect rates were around 12% and differed by no more than 1% between the 3 periods. The highest z-score, based on the differences between any two periods, was 0.71. The differences were therefore not statistically significant at a 95% confidence level.
- Major defect rates were highly variable but were all less than 3%. Numbers were too small for statistical testing (e.g only 5 vehicles in one group).
- Results for issue of cautions were similar to minor defect results.

Given these inconclusive results an analysis on accident rates would not be appropriate as it would not be possible to link any accident trends with the roadworthiness of the vehicles concerned.

Conclusions

Results for roadside inspections in the ACT are only available in summary form and do not cover the whole of the period of interest (1980 onwards). In any case, there are doubts about the suitability of available data due to sampling methods and possible confounding factors, such as increase in the number and profile of roadside inspections.

Subject to these reservations, the available data do not indicate any significant difference in the proportion of vehicles with minor defects over the period from December 94 to December 96.

Fosser's work in Norway suggests that, in the presence of an effective roadside inspection program, the accident rates of light vehicles are not influenced to any significant extent by periodic inspection programs.

Recommendations

It is considered that further analysis of the ACT roadside inspection statistics or accident trends would not be worthwhile due to the limited information available, the likelihood of bias in the sampling and the presence of confounding factors such as the introduction of a roadside inspection program.

It is recommended that consideration be given to a more rigorous random sampling program, repeated every few years along the lines of the NSW audit program.

Also, the results of a comprehensive study in Norway suggest that an *effective* roadside inspection program can be a substitute for a periodic inspection program, in terms of limiting the contribution of defects to road accidents. It is therefore important that the ACT retains its roadside inspection program. It is recommended that the recording systems for the roadside inspection program be improved so that more meaningful statistical analysis can be conducted (such a system could then also be used for the proposed audit work).

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