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Abstract

This study was undertaken to explore the underlying factors influencing the on-road behaviour of long distance truck drivers. A survey of 820 long distance truck drivers was conducted to collect the data for the study. Detailed information was obtained on the income of drivers, work routines in the industry, the incidence of schedules, and aspects of the driver's behaviour such as propensity to speed and the use of stimulant drugs. An econometric modelling system was developed to analyse the linkages between on-road performance and the economic rewards associated with the overall trucking activity and the competitive forces operating in the industry.

Keywords

Long distance truck drivers, driver behaviour, economic reward, road safety, speed, fatigue

Notes

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LONG DISTANCE TRUCK DRIVERS ON-ROAD PERFORMANCE AND ECONOMIC REWARD

by

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EXECUTIVE SUMMARY

1. Introduction

Over the past few years there has been increasing concern that the safety of our roads, particularly the national highways, has been decreasing. This is purported to be at least partly related to the unsafe on-road behaviour of long distance truck drivers. This view was influenced by the marked increase in fatal crashes involving semi-trailers in 1988. The media attention given to crashes involving long distance heavy vehicles has helped create a negative image of the long distance truck driver and the trucking industry as a whole. Although excessive speed and other unsafe on-road behaviour which increases the exposure to risk of all road users cannot be excused, the negative image of truck drivers has evolved with little, if any, questioning of the reasons behind that behaviour.

Investigations into the nature of the on-road behaviour of long distance truck drivers have tended to emphasise either the consequences of bad practice, notably crashes involving fatalities, or in a descriptive manner the nature of the structure, conduct and performance of the trucking industry as a whole. Ex post investigations seeking the "causes" tend to concentrate on the "localised" reasons as an explanation of the consequences. There is rarely any detailed inquiry into the "real causes" of these crashes. The real causes can only be identified by studying the long distance trucking industry as a whole, delving into its financial structure, the pressure points which contribute to inappropriate behaviour on the road, and the economic rewards associated with the overall trucking activity.

The current study evolved out of a concern that there is a lack of systematic scientific evidence, especially in relation to the underlying economic structure of the industry, to prove or disprove many of the offered hypotheses. Consequently we run the risk of regulatory authorities proposing inappropriate strategies to modify the on-road behaviour of the long distance trucking industry and to improve the safety of the road environment.

The aim of this study is to explore the linkages, if any, between economic reward and the on-road behaviour of long distance truck drivers. To fully explain the impact of a range of factors relating to economic reward and on-road behaviour an econometric modelling system was developed.

2. The study

This study involved a survey of 820 long distance truck drivers throughout Australia conducted during September and October 1990. Interviews were conducted in Sydney (456), Newcastle (117), Melbourne (98), Brisbane (98), and Adelaide (51). We found that interviewing in these locations gave us a sample of drivers which covered all the main routes (with the exception of the Northern Territory) in Australia. The oversampling on the eastern seaboard reflects the high volume of freight carried in the Sydney - Melbourne and Sydney - Brisbane corridors and the greater public exposure to risk on these routes due to the high level of general traffic.

Data was collected from each driver in an indepth face to face interview. The main focus of the study was to collect data directly from truck drivers to establish first hand the economic conditions under which they work. The central feature of the survey instrument was the collection from each driver of the details of a specific trip. This was usually the last one-way trip completed by the driver. Details were collected about the activities undertaken before and after the trip, and the time, place, length and reason for each stop on the trip. This approach was used to obtain the information necessary to assess the actual conditions faced by drivers on the road in order to identify associations between the dimensions of speed, economic conditions, and scheduling and other, either self or externally imposed, time constraints.

Interviews were undertaken at the main origin and destination points of trips rather than at en-route stopping places. This was for a number of reasons. Firstly, drivers waiting at these sites to pick up a load had the time available to be interviewed and were thus more inclined to stop for what was a 30 to 60 minute interview at this stage of their trip rather than if they were still en-route and had to meet a scheduled time of arrival. It was also found that a greater range of drivers could be interviewed at these sites than if particular en-route stops were selected. The main type of driver which was not represented in the sample of interviews at general loading sites was the large company driver. Thus the co-operation of some of the large road freight companies was sought which gave us permission to interview their drivers at their own loading depots.

3. Profile of the sample

The sample included owner drivers, 38%, and employee drivers, 62%. The owner drivers were classified as fleet owners, painted or regular subcontractors, independent subcontractors and independent owner drivers. Employee drivers were classified by size of company according to the number of trucks in the company.

The age distribution of drivers in the sample indicated that they are concentrated in the middle age brackets, with only a small percentage in the youngest and oldest age brackets; 5% of all drivers were less than 24 years of age and 3.5% over 55 years. This distribution is similar to that of the general working population suggesting that, contrary to popular beliefs, truck drivers are not all young irresponsible "cowboys".

Overall 70% of drivers in the sample had 10 or more years experience driving large trucks. Only 8% of drivers had less than 5 years experience. The average number of years for the sample was 14.88. This highlights the large and stable population of drivers who are committed to the industry.

For the sample 25% of drivers had always been a truck driver with no previous occupation. For the others a range of occupations were represented, primarily the trades, farmers and general labourers, but also a significant number of managerial and professional positions.

We found that the majority of long distance drivers drove between 100,000 and 200,000 kms per annum. The average number of kilometres for the sample was 197,166 kms per year. The small and medium sized company drivers were more likely to drive in excess of 200,000 kilometres per year than were the owner drivers or employee drivers of the large companies.

The majority of drivers in the sample earn between $15,000 and $50,000 per annum. Owner drivers were more strongly represented in the lower income brackets. Overall, 62% of owner drivers earned less than $32,000 in the financial year 1989-1990, with 50% earning less than $22,000. This compares with 19% of small company employee drivers, 12% of medium company employee drivers and 0% of large company drivers who earned less than $22,000. Employee drivers were found predominantly in the middle income ranges of $22,000 to $50,000, but 66% of large company drivers earned between $32,000 and $50,000 a year.

4. Results of the descriptive analysis

This section presents the major findings of the descriptive analysis of the survey. The main variables which formed the basis for the hypotheses for the econometric modelling analysis are discussed. These include propensity to speed, the constraints imposed by schedules, the possible incidence of fatigue as a result of a demanding work routine, and the use of stimulant drugs. Conclusive evidence of the links between the on-road performance of the long distance truck driver and underlying economic conditions in the industry cannot be drawn from this analysis. However it is valuable in providing a background to the factors which were analysed in the econometric models.

The average speed of the driver's trip was calculated for the specific trip by dividing the total kilometres of the trip by the driving time for the trip. The mean speed for the whole sample was 81.06 kph. The average speed for each driver type was: large company drivers 79.81 kph, medium company drivers 80.92 kph, owner drivers 81.01 kph and small company drivers 82.01 kph. Overall small company drivers appear to travel at faster speeds on average compared to the other driver types, and large company drivers travel at slower speeds.

About 35% of all drivers in the survey had a given scheduled time of arrival for their trip. There was very little variation in the incidence of schedules across the different types of drivers. Owner drivers had the highest proportion with a scheduled time of arrival (40.3%), and large company drivers the lowest (32.0%).

Drivers were also asked if it was important for them to arrive at their unloading point before a particular time even if it was not scheduled by an employer or freight forwarder. Approximately 60% of all drivers reported that it was important for them to arrive at a certain time, even if a schedule had not been set by the freight forwarder or the owner of the freight. There was very little difference according to the type of driver. The most important reasons given for imposing their own scheduled time of arrival revolved around the importance of being in the queue or being unloaded ready to take on the next load. These constraints are for the most part self-imposed, but are most likely to be a symptom of the underlying economic pressures in the industry.

Drivers were asked how many hours a week they spent earning a living as a truck driver. These hours include all activities undertaken in order to earn a living from truck driving. As well as actual driving time, drivers are also often responsible for loading and unloading their truck, organising the load, and repairs and maintenance on the truck. The hours ranged from 20 hours per week to 168 hours per week, with an average for the total sample of 105 hours per week. Some drivers, particularly owner drivers, considered that they worked a 24 hour day up to 7 days per week. Even when they were not driving or loading they felt that they were "on duty" waiting for loads, snatching sleep in their truck whenever they could. Twenty-two percent of the sample said that they worked 140 hours or more per week and only 4% of the sample considered that they worked less than 60 hours per week.

The distribution of hours worked per week was very similar for owner drivers and for employee drivers of small and medium sized companies. However amongst larger company employee drivers the majority of drivers worked between 60 and 100 hours per week, but 24% of large company employee drivers still worked over 120 hours per week.

Drivers were also asked to estimate the percentage of total work hours they spent driving. The percentage of hours spent driving for the whole sample ranged from 14% to 100%, with an average of 65%. Employee drivers spent on average 67% of their work time driving, whilst for owner drivers the mean was 61%. The average number of driving hours per week for all drivers was 67 hours per week. Small company drivers drove the most hours per week (average of 72 hours), and large company drivers the least (average of 61 hours). This most likely reflects the fact that the large companies have loading and unloading staff and maintenance workers at depots who prepare the truck for the driver, thus taking a lot of the pressure off the driver by reducing his working time and thus fatigue levels.

The activities undertaken by a driver before setting out on a long trip may render the driver fatigued before he begins the driving task. Thus knowledge of the driver's activities in the hours prior to commencing the trip can provide useful information in the search for influences on on-road performance. In relation to the specific trip selected by each driver, drivers were asked about their activities in the 8 hours prior to departure on that trip. This information highlighted the extremely demanding and stressful workload of the driver when off the road.

The main off-road activity undertaken by most drivers is loading and unloading the truck. Forty-three percent of drivers spent some time loading their truck or waiting for the truck to be loaded. Of these drivers, 13.3% carried out the loading on their own, spending between 1 and 2 hours loading. Sixty percent of drivers supervised and assisted the loading with a forklift driver, taking them on average 3 to 4 hours. Thus even before leaving on their trip these drivers had already spent a significant time doing physically tiring work.

In total approximately 42% of time was spent on work related activities in the last 8 hours before departure for the trip, such as loading for the trip, unloading from the previous trip or maintenance on the vehicle. This amounts to an average of 3 hours 20 minutes of the last 8 hours prior to departure spent on work related activities. On average drivers spent 31.9% of time sleeping in the 8 hours prior to their departure on the sampled trip, which is equal to approximately 150 minutes sleep. Large company drivers had the most sleep, spending 43% of the last 8 hours sleeping. Medium company drivers slept for 33.1% of the 8 hours, owner drivers 29.1% of the 8 hours, and small company drivers, 28.5%.

It is a widely held belief that many long distance truck drivers resort to taking stimulant drugs to maintain alertness on long trips. The findings in this study confirmed this belief. A significant proportion of drivers admitted to taking stimulants to stay awake whilst on long trips. Of the drivers interviewed 8.8% took stimulants on every trip, with 37.3% taking them on some trips. In total 46.1% of drivers interviewed take stimulants at least on some trips. Our data suggests that owner drivers take drugs the least, with 7.4% taking them on every trip and 30.3% taking them sometimes. A higher percentage of small company drivers than any other driver type admitted to taking stimulants with 11.5% taking them on every trip and 48.5% taking them sometimes. A similar proportion of medium company drivers took pills on every trip, 11.7%, with 36.7% taking them sometimes. Only 3.3% of large company drivers take pills on every trip, with 37.7% taking them sometimes.

5. Results from the econometric modelling

Given that there are a number of complex inter-relationships which contribute to the ultimate on-road performance of truck drivers (Hensher and Battellino 1990), the separation of the major sources of influence can only satisfactorily be achieved by a formal quantitative investigation using suitable econometric techniques capable of eliciting the causal relationships.

The analysis of the data required a complex set of structural equations to be developed to represent the two-way causality inherent in the sources of influence on the driver's behaviour on the road. The critical behavioural dimensions which require explanation are the economic rewards (annual income net of expenses), the overall number of hours of work required to return an acceptable income, the number of productive driving hours, the incidence of speeding, the extent of fines for speeding in particular and its links with economic return, the incidence of pill taking and self-imposition of schedules and its linkage with on-road performance with respect to sources of exposure to risk.

Two econometric model systems were developed to study the underlying influences on economic rewards and exposure to risk. The first model system looks at economic reward, using variables of earnings, driving hours, total work hours, and the number of speeding and log book fines in the last 12 months. The second model system examines the exposure to risk the driver faced on the specific trip analysed, such as the speed of the trip, the incidence of stimulant use, and whether the driver had a self-imposed schedule.

The major finding from the econometric analysis was that the economic rewards to both owner drivers and employers of drivers were found to have a major influence on the propensity to speed; but that in particular:

(i) It is the rate received for freight per se which acts to stimulate road practices in various forms in order to ensure that an acceptable level of total earnings (net of truck-related expenses) is obtained. Any deviation from a fixed salary tends to encourage practices designed to increase economic reward which are not synergetic with reducing exposure to risk.

(ii) The uncertainty of regular earnings encourages the practice of self-imposed schedules and the taking of stimulants to enable extension of the productive working week. While the extended working week does increase the earnings, the incidence of productive (i.e. driving) time decreases as total working hours increases. Any strategy which can reduce the uncertainty of earnings must reduce the hours of total work, increase the amount of sleep time and consequently reduce the incidence of self-imposed schedules and hence the use of stimulants.

Regular contracts are a preferred form of load allocation, initially obtained by a process of competitive bidding, with possibly relatively short contracts in order to ensure that bid prices remain competitive. This may be the only way to minimise the amount of unproductive waiting time and to eventually prune the industry. Major implementation of competitive bidding in other transport industries is seen as a preferred alternative to complete economic deregulation primarily because of the inability of deregulation to manifest an acceptable program of internalising the negative externalities of unfettered competition.

Loan repayments on a truck are a major financial commitment for owner drivers. For owner drivers strategies to ensure that the financing of trucks is achieved with least burden must improve the net earnings of the owner driver sector.

The anecdotal evidence which tends to lay the blame for bad on-road behaviour on owner drivers is fallacious. Small company employee drivers have some of the worst industry practices in respect of speeding, use of stimulants and incidence of fines. Indeed many of the influences on variations in on-road performance, pill taking and self-imposition of schedules which often lead to speeding are not correlated with whether a driver is an owner driver or an employee driver. The distinction between owner driver and employee driver is somewhat arbitrary and misleading in the current context. A much more useful classification is in terms of the nature of contracts.

Lifestyle factors appear to have evolved as a result of the ease of entry to the industry coupled with its highly competitive nature which demands non-routine and unpredictable work practices for a significant number of drivers in the industry. There appears to be a case for much more stringent safety regulations centred on the health of the driver as distinct from the "health of the rig". There is a great temptation for commentators to argue that if someone wants to enter this industry, get burdened with high debts and work excessive hours to "make a quid" then they should be allowed to. This may be acceptable wisdom if safety of human resources at large were not at risk. It is precisely because of the negative externalities aligned to safety that changes are required in the competitive practices. The transactions costs are sufficiently high to warrant some restrictions on competitive practices in the market. Competition for the market should be given serious consideration.

6. Conclusions

The influences on the performance of long distance truck drivers in Australia are related in a complex way. Although the centrepiece of a causal system is the linkage between potential earnings, lifestyle and pressures imposed on a driver by employers and the marketplace, there are some very explicit influences impinging on safe practices on the road where safety and exposure to risk are adequately represented by variations in average trip speed across the population of truck drivers.

The data obtained from 820 truck drivers are used herein to establish a first round understanding of some of the major endogenous linkages and exogenous determinants on safe practice in respect of a particular trip and its links with the macro environment for annual earnings. This has enabled us to scientifically investigate a large number of the anecdotes and qualitative "evidence" previously used to develop positions in respect of strategies to "rid the industry and the road environment of cowboys".

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1. INTRODUCTION

1.1 Background to the study

In September 1989 the Transport Research Centre (TRC) at Macquarie University was funded as a seeding grant by the Federal Office of Road Safety to undertake a pilot survey of long distance truck drivers in Australia. This pilot was to be the forerunner of a major survey of long distance drivers throughout Australia.

The main survey was conducted during September and October 1990. This report presents the findings of that survey. The report has been prepared by the Institute of Transport Studies (ITS), University of Sydney as, since the pilot survey, the principals of the TRC who were working on this project have moved to ITS. The fieldwork for both the pilot survey and the main survey was undertaken by National Survey Research Pty Ltd.

Over the past few years there has been increasing concern that the safety of our roads, particularly the national highways, has been decreasing. This is purported to be at least partly related to the unsafe on-road behaviour of long distance truck drivers. This view was influenced by the marked increase in fatal crashes involving semi-trailers in 1988 and by a particularly severe crash between a semi-trailer and an interstate scheduled coach which claimed the lives of 20 people and injured 18 passengers in October 1989. In 1988, there were 151 fatalities in New South Wales resulting from crashes involving semi-trailers. This was twice the number in 1987. The high rate of fatalities continued in 1989 with 143 people killed in crashes involving semi-trailers, however this has fallen to 94 in 1990.

The increased involvement of articulated vehicles in fatal crashes in 1988 and 1989 appears to have been confined primarily to NSW. Table 1 shows the number of fatal crashes involving at least one articulated vehicle by state from 1981 to 1990. The 1988 figure for NSW represents a marked reversal of the trend of the previous 7 years. The number of crashes in 1989 declined from the 1988 high, but was still well above the 1987 level. However, the number of crashes fell significantly in 1990 suggesting that the 1988 and 1989 figures were not necessarily indicative of a worsening road safety problem, but rather were aberrations in a generally stable environment. There was a slight increase in fatal crashes in Victoria in 1987 and 1988, however the number of crashes in 1989 and 1990 show a decline. There has been little if any change in the number of fatal crashes involving an articulated vehicle in any of the other states over the period shown in Table 1.

Table 1 Fatal crashes involving at least one articulated vehicle

	NSW	VIC	QLD	SA	WA	TAS	NT	ACT	AUST
1981	113	44	47	11	12	4	na	na	231
1982	114	39	53	17	19	3	1	0	246
1983	105	42	29	15	15	7	1	0	214
1984	113	45	34	21	13	4	0	0	230
1985	98	36	36	18	17	8	1	0	214
1986	77	39	37	16	15	8	0	0	192
1987	59	52	36	28	16	4	0	0	195
1988	120	54	47	16	7	5	0	1	250
1989	99	32	44	18	22	4	3	1	223
1990	74	44	28	15	17	8	3	0	189

Source: 1990 Road Fatality Statistics Australia, Federal Office of Road Safety

The marked increase in fatalities and fatal crashes involving articulated vehicles in NSW in 1988 has been the subject of a major government inquiry (FORS 1990). This study found that the major crash types contributing to the 1988 increase were found in high speed zones on undivided roads. The problems caused by the condition of the road, specifically related to the narrowness of the road, number and type of curves and undivided sections were particularly acute on the Pacific Highway, but were also found on parts of the Hume Highway. These problems with the condition of the road were found to be a major contributor to the increase in the number of crashes in 1988. Other factors which were considered important in increasing the number of crashes were the increased general level of traffic and freight flows, and poor driving behaviour on the part of car drivers and truck drivers. In particular inattention resulting from driver fatigue, of both car and truck drivers, and high speeds were significant contributors to crashes involving heavy vehicles.

Table 2 outlines some crash statistics for NSW for the period 1986 to 1990. These figures highlight not only the absolute increase in the number of fatalities resulting from articulated vehicle crashes but also the increase in the number of fatalities per registered articulated vehicle and also per crash involving an articulated vehicle. The increase in the fatalities per crash in 1989 reflects the crash between an articulated vehicle and a coach on the Pacific Highway in which many of the coach passengers were killed. The number of crashes per registered articulated vehicle is based on the number of articulated vehicles registered in NSW. These vehicles however travel extensively throughout the other states and likewise vehicles registered in other states travel extensively in NSW. Perhaps a better indicator of exposure to risk is the number of crashes per vehicle kilometre. The annual articulated vehicle kilometre figures given in Table 2 for the 16,800 articulated vehicles registered in NSW in 1990 indicate an annual vehicle kilometre total of around 86,000 kms per vehicle. This is considerably less than the average found in our sample of drivers, which was around 197,000 kms per annum. If we use the average annual kilometre figure from our sample for the vehicles registered in NSW this suggests a rate of 0.028 fatalities per million articulated vehicle kilometres. Thus the incidence of crashes relative to exposure on the road is very small and represents an impressive safety record.

Table 2 *NSW crash statistics - 1986 to 1990*

	1986	1987	1988	1989	1990
Total number of people killed	1029	959	1037	960	797
Fatalities from articulated vehicle crashes	96	75	151	143	94
No. of articulated vehicle occupants killed	31	19	30	32	22
Total fatal crashes	908	858	912	783	702
Fatal crashes involving articulated vehicles	77	59	120	99	74
Total single vehicle fatal crashes	315	318	292	252	238
Total single articulated vehicle crashes	18	9	20	14	15
Alcohol related fatal crashes	236	200	199	175	175
Fatal crashes in speed zone <60 kph	461	426	475	381	339
Fatal crashes in speed zone 80 kph	85	74	78	54	93
Fatal crashes in speed zone 100 kph	329	327	337	312	238
Fatal crashes in unknown speed zone	25	15	11	6	7
Total vehicle registrations (x 10^9)	3.03	3.04	3.08	3.17	3.22
Total articulated vehicle registrations (x 10^3)	17.4	16.6	16.1	16.7	16.8
Total annual vehicle kms (x 10^9)	47.526	47.550	48.194	52.950	53.892
Total annual articulated vehicle kms (x 10^6)	1379.8	1380.5	1399.2	1440.4	1447.8
Truck fatalities per 1000 truck registrations	5.5	4.5	9.4	8.6	5.6
Truck fatalities per truck fatal crashes	1.25	1.27	1.25	1.44	1.27

Source: NSW Traffic Authority Annual Statistics - 1986, 1987;
Roads and Traffic Authority Road Traffic Accidents in NSW - 1988, 1989, 1990.

There was evidence in the FORS study into heavy vehicle crashes in NSW in 1988 that excessive speed on the part of truck drivers was important in contributing to the increase in fatal crashes involving heavy vehicles. It is the aim of this study to firstly establish further evidence as to the speed behaviour of truck drivers and then to explore the possibility of links between the propensity of a driver to speed and the economic conditions in the industry in general and the driver's own particular economic operating environment.

The media attention given to crashes involving long distance heavy vehicles has helped create a negative image of the long distance truck driver and the trucking industry as a whole. Although excessive speed and other unsafe on-road behaviour which increases the exposure to risk of all road users cannot be excused, the negative image of truck drivers has evolved with little, if any, questioning of the reasons behind that behaviour. We do not believe that it is reasonable to assume that all operators in the industry are irresponsible cowboys, who spend long hours speeding along the highways without thought for their own or other road users' safety. This study also aims to determine a profile of the long distance trucking industry and to reveal the characteristics of the general population of drivers. It is not disputed that there is likely to be a "cowboy" element amongst drivers but it is maintained that this element represents a minority in the industry, whose behaviour has coloured the reputation of the majority of drivers.

Theories and anecdotes about the causes of unsafe on-road behaviour of heavy vehicle drivers abound. This "evidence" may be suitable in illustrating case specific behaviour, but is potentially dangerous in its representation of the behaviour patterns within the industry as a whole. It is also dangerous as a basis for sound policy decision making. Often "band-aid" policies are introduced in response to a particular incident receiving public attention. For example immediately following the October 1989 truck and coach crash on the Pacific Highway the speed limit for heavy vehicles was reduced from 100 km per hour to 90 km per hour.

Investigations into the nature of the on-road behaviour of long-distance truck drivers have tended to emphasise either the consequences of bad practice, notably crashes involving fatalities, or in a descriptive manner the nature of the structure, conduct and performance of the trucking industry as a whole. There is a dearth of *substantive* studies directed towards an enquiry into the underlying causes of on-road behaviour and hence levels of exposure to risk of a crash.

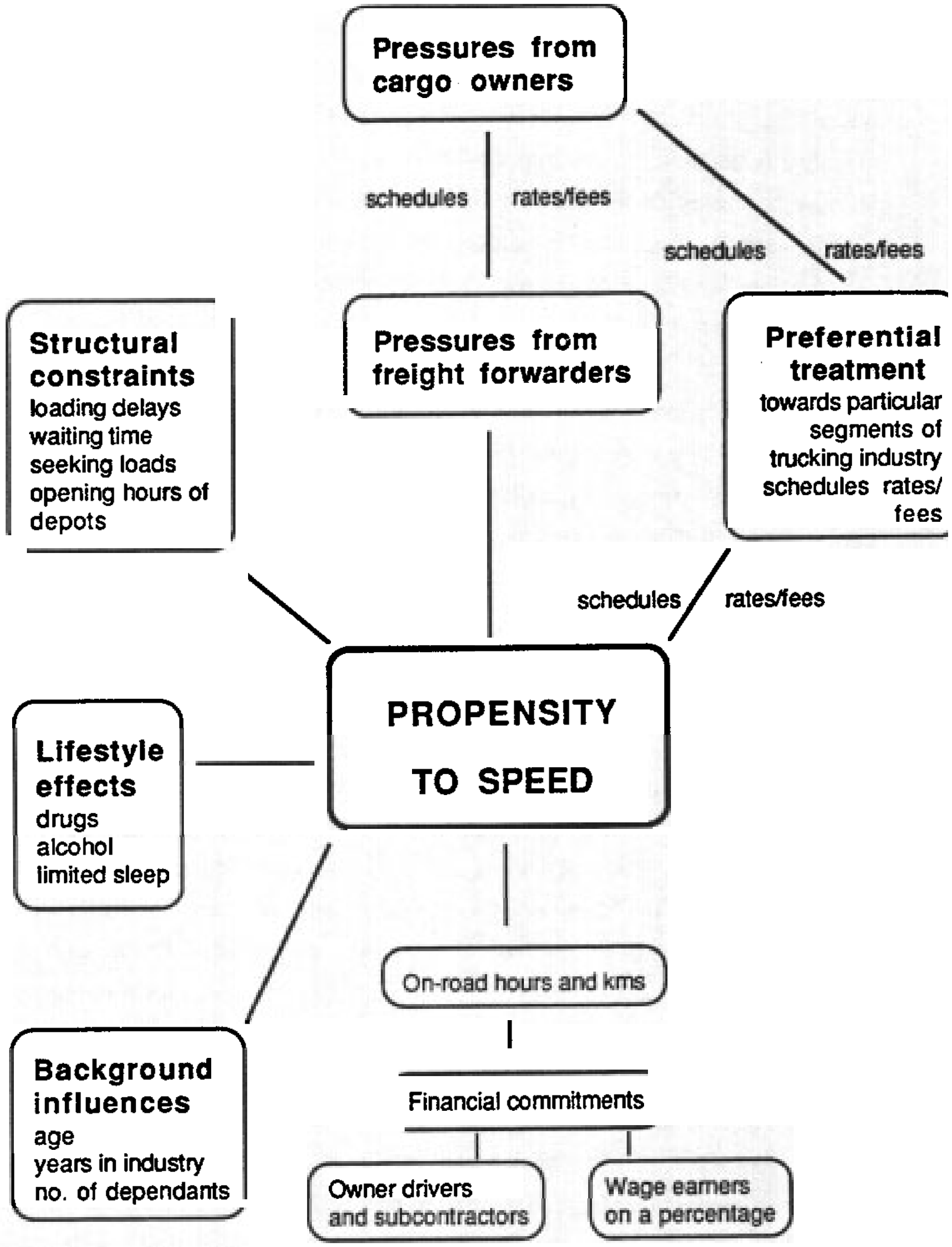
When a truck is involved in a crash, especially if injury or fatality occurs involving third parties such as pedestrians and automobile occupants, there is an immediate set of causes offered in the media. Typically the "causes" include the condition of the roads, the excessive speed of the vehicle, the use of pills to prolong driving hours, and the lack of training of independent owner drivers. As we continue to witness crashes involving trucks, any ex post investigations seeking the "causes" tend to concentrate on the "localised" reasons as an explanation of the consequences. There is rarely any detailed inquiry into the "real causes" of these crashes. The real causes can only be identified by studying the long-distance trucking industry as a whole, delving into its financial structure, the pressure points which contribute to inappropriate behaviour on the road, and the economic rewards associated with the overall trucking activity (including the competitive nature of load-acquisition).

The current study evolved out of a concern that there is a lack of systematic scientific evidence, especially in relation to the underlying economic structure of the industry, to prove or disprove many of the offered hypotheses. Consequently we run the risk of regulatory authorities proposing inappropriate strategies to modify the on-road behaviour of the long distance trucking industry and to improve the safety of the road environment.

1.2 Study method

This study involved a survey of over 800 long distance truck drivers throughout Australia. Data was collected from each driver in an indepth face to face interview. Descriptive analysis of the sample data was undertaken using a standard statistical package. However, given that there are a number of complex inter-relationships which contribute to the ultimate on-road performance of truck drivers (Hensher and Battellino 1990), the separation of the major sources of influence can only satisfactorily be achieved by a formal quantitative investigation using suitable econometric techniques capable of eliciting the nature of cause and effect. The interactions between the major elements of the study are summarised schematically in Figure 1. The critical dimensions which require explanation are the economic rewards (annual income net of expenses), the overall number of hours of work required to return an acceptable income, the number of productive driving hours, the incidence of speeding, the extent of fines for speeding in particular and its links with economic return, the incidence of pill taking and self-imposition of schedules and its linkage with on-road performance with respect to sources of exposure to risk.

Figure 1 Relationship between the major elements of the study



1.3 Structure of the report

This report presents descriptive and modelling analysis of the data collected in the survey of 820 drivers. The survey method and fieldwork procedures are outlined in Section 2 of this report. The socio-economic characteristics of the sample are described in Section 3. Section 4 examines some of the factors which have an influence on the economic reward received by drivers. Some indicators of exposure to risk such as evidence of speeding, involvement in crashes and time spent on the road will be looked at in Section 5. The major purpose of Section 4 and Section 5 is to give some background detail for the variables used in the econometric analysis in the following section. Section 6 discusses the results from the econometric analysis of the underlying relationships that influence the economic rewards and the on-road performance of the drivers in the sample. The major findings and conclusions are reported in Section 7.

2. SURVEY METHOD

The main focus of the study was to collect data directly from truck drivers to establish first hand the economic conditions under which they work. The main survey was preceded by a pre-pilot skirmish and a pilot survey which were essential in developing the hypotheses to be tested and thus in determining the data collected in the main survey.

The pre-pilot skirmish and the pilot survey are discussed in a previous report (Hensher et al 1989). The survey method to be used, that is a face to face survey instrument, and the location of the main survey site in Sydney were decided upon as a result of the findings of the pilot survey and are briefly described below.

2.1 The survey method

In the pilot survey mail back questionnaires were distributed and face to face interviews were undertaken. A comparison of the responses to both these methods revealed greater reliability and accuracy could be achieved by using face to face interviews. The face to face interviews also encouraged more insightful responses to the open ended questions in the survey as truck drivers were more willing to talk about the issues which concerned them rather than to write about them at length. We found no difficulty in enlisting the co-operation of drivers to take part in the interviews. This was partly because we interviewed at loading and unloading sites where drivers had the time available to take part in the survey while waiting for a load. Also the survey was presented as university research focusing on the views of drivers. They thus appreciated the opportunity to talk to an impartial body about their industry.

2.2 Interviewing sites

Interviews were conducted in Sydney, Newcastle, Melbourne, Adelaide and Brisbane. The experience in the pilot survey of interviewing at a major loading/unloading site in Sydney confirmed our commitment to interviewing at the main origin and destination points of trips rather than at en-route stopping places. This was for a number of reasons. Firstly, as mentioned above, drivers waiting at these sites to pick up a load had the time available to be interviewed and were thus more inclined to stop for what was a 30 to 60 minute interview at this stage of their trip rather than if they were still en-route and had to meet a scheduled time of arrival. It was also found that a greater range of drivers could be interviewed at these sites than if particular en-route stops were selected. This was not only more efficient from an interviewing point of view, but also avoided the sample selectivity bias which results from only interviewing at particular road side sites. Quite often truckies have their "favourite" stopping place and sites are often frequented by particular types of drivers. Interviewing at general loading depots provided a representative sample of drivers which included owner drivers and employee drivers from small and medium sized companies.

The main type of driver which was not represented in the sample of interviews at general loading sites was the large company driver. Thus the co-operation of some of the large road freight companies was sought for permission to interview their drivers at their own loading depots. This gave us a sample of large company drivers and also owner drivers who are subcontracted by the company.

Interviews in Sydney and Melbourne were conducted at general loading depots and also at the depots of the large freight companies. In the other capital cities, Brisbane and Adelaide, interviews were conducted at truck stops located close to the general loading sites and company depots. These were sites where it was found drivers often waited whilst arranging their next load. A list of the interviewing sites is included in Appendix 1.

2.3 The sample

A sample of 820 drivers was interviewed: 456 in Sydney, 117 in Newcastle, 98 in Melbourne, 98 in Brisbane, and 51 in Adelaide. We found that interviewing in these locations gave us a sample of drivers which covered all the main routes (with the exception of the Northern Territory) in Australia. The oversampling on the eastern seaboard reflects the high volume of freight carried in the Sydney - Melbourne and Sydney - Brisbane corridors and the greater public exposure to risk on these routes due to the high level of general traffic. The Hume Highway carries 50% of road freight by volume and the Pacific Highway carries 18% (BTCE 1990). The main routes sampled are included in Appendix 1.

The sample included owner drivers - 38%, and employee drivers - 62%. The owner driver sample was stratified according to fleet owner, painted or regular subcontractor, independent subcontractor and independent owner driver. Employee drivers were classified by size of company according to the number of trucks in the company. Drivers employed by companies ranging from 1 to over 200 trucks were included in the sample. The characteristics of the sample will be discussed further in Section 3 of this report.

2.4 The questionnaire

A copy of the questionnaire is included in Appendix 2. A central feature of the questionnaire is the question which collects details of the driver's most recent trip, particularly of the time, place, purpose and duration of each stop on the trip. Information was also collected on the type of cargo being carried and the freight rate received for that cargo, any scheduling requirements, loading and unloading arrangements and the activities undertaken by the driver in the eight hours before leaving on the trip. Given the distance and time between each stop on the trip the average speed at which the driver was travelling can be calculated for each leg of the trip and for the entire trip. Two alternative definitions of speed were analysed, firstly the total average trip speed, and secondly the standard deviation of the speeds across the trip legs. The two different measures of speed and the factors which might influence the driver's propensity to speed were analysed. These issues will be discussed further in the results of the econometric modelling in Section 6 of this report.

3. DESCRIPTION OF THE SAMPLE

In this section the sample will be described in terms of a number of socio-economic variables and variables describing the type of driver and their experience in the industry. This information is useful not only for providing contextual data for the econometric analysis of the factors which influence on-road behaviour, but also in providing a profile of the population of long distance truck drivers. Very little is known about the population of long distance drivers. Surveys to date have concentrated on a particular type of driver or an aspect of driver behaviour. There are many anecdotes about the character of the long distance truckie, but these tend to emphasise the "cowboy behaviour" of drivers which may not be typical of the majority of drivers.

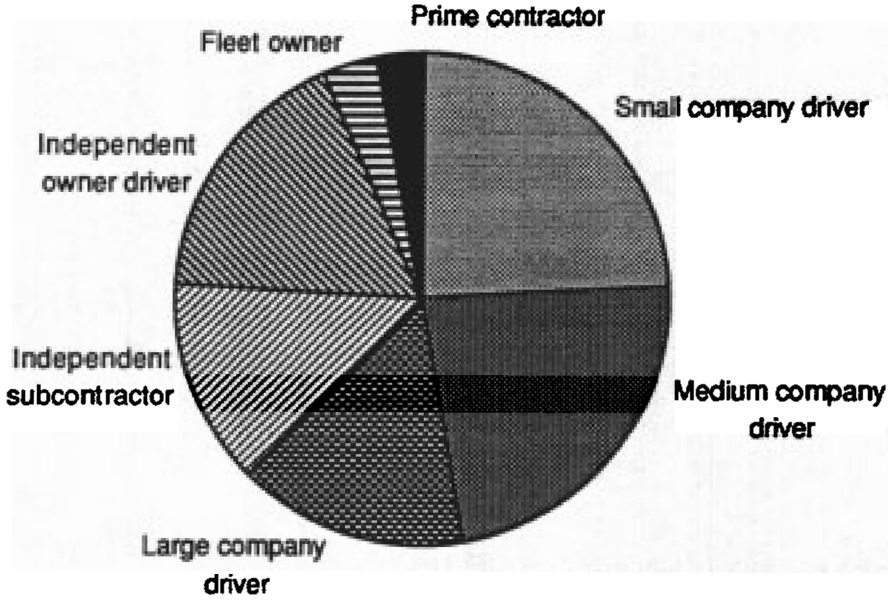
Some summary statistics of the sample are presented below in graphical form. The accompanying tables for these graphs are given in Appendix 3. Tables of the frequencies of all the major variables are given in Appendix 4.

3.1 Type of driver

Of the sample 38% were owner drivers and 62% were employee drivers. There is no available data on the breakup of owner drivers and employee drivers in the industry as a whole. Consequently, it is not possible to say if this sample is fully representative of the industry population. Owner drivers were further classified as fleet owners, prime contractors, subcontractors and independent owner drivers. Company drivers were classified into small, medium and large company drivers according to the number of trucks in the company. The distribution of the types of drivers found in the sample is shown in Graph 1.

Seventeen percent of drivers in the sample were independent owner drivers. This is defined as not having a regular contract for at least some of their loads so that each load has to be arranged. As a percentage of owner drivers 46% were independent owner drivers. Although these drivers may establish some regular contacts with freight forwarders there is no guarantee when the next load will be available, at what rate it will be offered or what is the destination of the load. This is a much more precarious situation than that of the subcontractor who at least has a regular contract for some loads and thus a partially guaranteed source of income. Independent subcontractors made up 14% of the total sample of drivers and represented 37% of owner drivers.

Graph 1 Distribution of type of driver in the sample



The prime contractor, also known as a painted contractor, is permanently contracted either by a company or a freight forwarder and has the name of that company or freight forwarder painted on his truck. Although he owns his vehicle he has a guaranteed source of work with one company. However only 3% of all drivers, or 8% of owner drivers, interviewed were in this category.

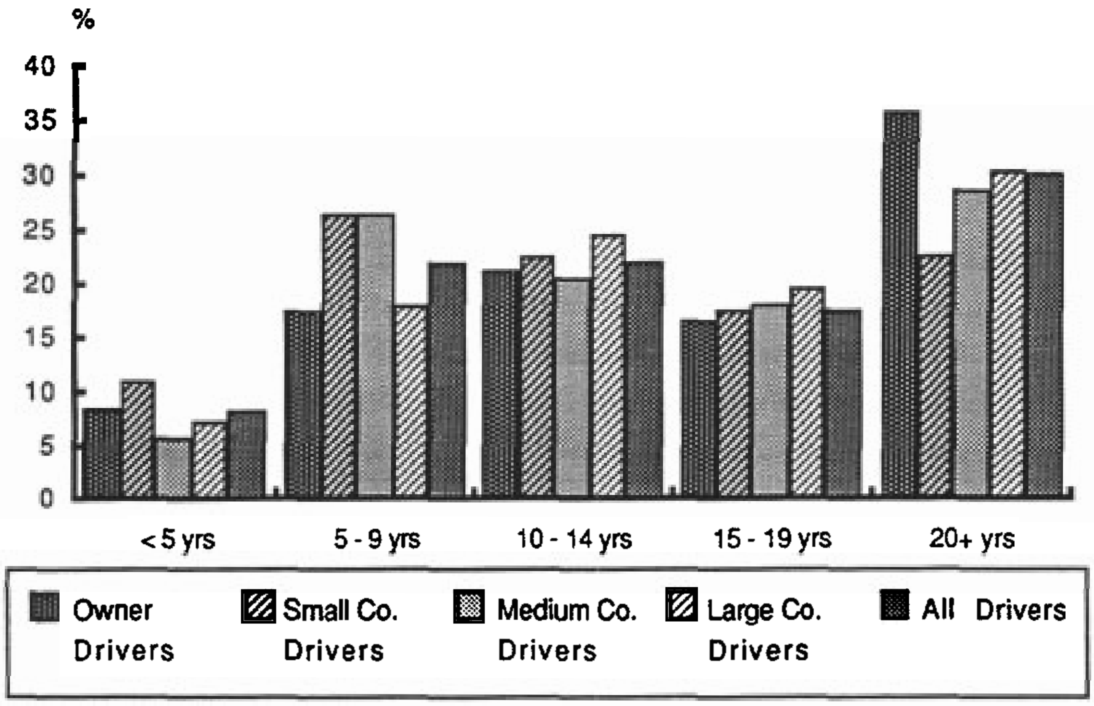
Drivers were classified as fleet owners if they were the owner of more than one truck. Only 28 drivers, or 3% of all drivers, were in this category. This category represented 9% of owner drivers. Eight fleet owners had 2 trucks (28.6%), 9 had 3 to 4 trucks (32.1%), 10 had 5 to 9 trucks (35.7%) and 1 had 20 trucks (3.6%). The greater the number of trucks in the fleet the less time the fleet owner would spend driving himself, and thus there is less chance of fleet owners with large fleets having been interviewed for the survey.

Employee drivers were grouped by size of company according to the number of trucks. Of the employee drivers in the sample 39% were from small companies (1 to 5 trucks), 37% from medium companies (6 to 29 trucks) and 24% from large companies (30 or more trucks). These percentages do not necessarily represent the distribution of these sizes of companies found in the general population of truck drivers as these interviews were not conducted randomly. We specifically included in our sample interviews with the large truck companies so as to provide a representation from that sector of the industry.

3.2 Years of experience

The distribution of years of experience driving large trucks on a regular basis for the whole sample is given in Graph 2.

Graph 2 Years of experience driving large trucks



Overall 70% of drivers have 10 or more years experience driving large trucks. Only 8% of drivers have less than 5 years experience. The average number of years for the sample was 14.88. This highlights the large and stable population of drivers who are committed to the industry. When classified by type of driver there was very little difference in the distribution of years of experience. However of small company drivers, 11% had less than 5 years experience, indicating that this is probably a common entry point to the industry. Of owner drivers 36% had over 20 years experience. This confirms previous findings and beliefs that owner drivers do not readily leave the industry. This is often explained by their strong commitment to the lifestyle, but other factors such as the high level of financial investment in their truck and lack of other employment opportunities may also pose significant barriers to exit from the industry.

Many studies talk about the high turnover rate of drivers in the trucking industry (AUSTROADS 1991). We endeavoured to find evidence from various sources of this turnover but to our knowledge no concrete data exists. Information from the Insolvency and Trustee Service Australia (ITSA) on bankruptcies seems to indicate that the number of drivers declaring themselves or their business bankrupt in 1989/90 was only a very small proportion of the total number of participants in the industry. Throughout Australia in 1989/90, approximately 3% (110) of all business bankruptcies were truck driving businesses, and approximately 1.5% (103) of people who filed for non-business bankruptcy were drivers. There is no distinction made in the ITSA data as to the type of driving business, for example type of vehicles used, short as compared to long distance work, or size of business. However, there did seem to be some evidence of an increase in the number of bankruptcies in the industry since 1987/88.

The Transport Commission of Western Australia (1985) investigated entrants and exits from the hire and reward business using trucks of at least 2 tonne tare between 1 May 1983 and 30 April 1984. Although the study did not focus exclusively on long distance truck driving, it provides some information on turnover in the road transport industry. The study estimated that 350 new businesses (with 1.12 trucks per operator) commenced operations in the 1 year study period, representing about 3.0% of all trucks in the hire and reward business in that state. In the same period, 327 existing business (1.26 trucks per operator) representing 3.15% of the total truck population left the industry.

From the exit survey, it was estimated that the average length of stay in the industry was 6.6 years, with 11% of operators exiting before 1 year, a further 17% before 2 years, and over half (52%) before 5 years. These results were confirmed by the entrant survey. When the entrant survey was held in May/June 1984, 12% of potential respondents (new entrants to the industry in the previous 12 months randomly selected from registration records) had already left the industry, with a further 10% intending to leave within 12 months.

There was considerable balance between the characteristics of entrants and exits. Several points were notable: the performance of prime contractors was noticeably better than that of subcontractors; and short haul operators performed considerably better than long haul operators, with the main feature being the relatively very poor performance of long haul subcontractors.

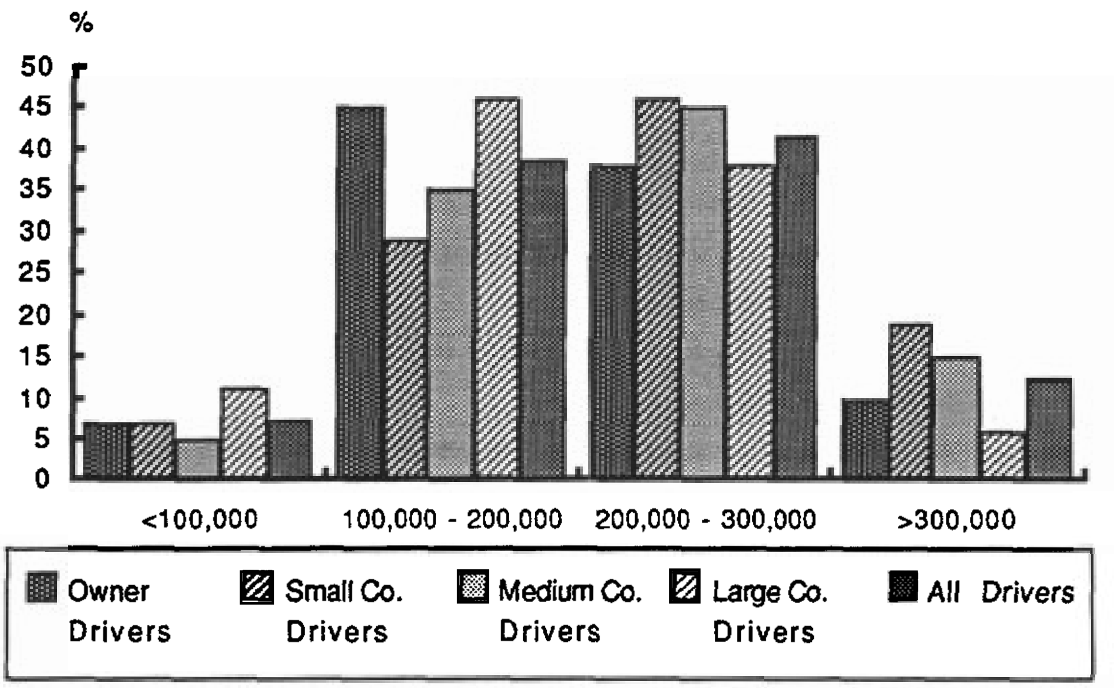
3.3 Annual kilometres

In the pilot study, the majority of long distance drivers drove between 100,000 and 200,000 kms per annum. The average number of kilometres for the sample in this study was 197,166 kms per year. Thirty-nine percent of all drivers drove between

100,000 and 200,000 kms and 42% drove between 200,000 and 300,000 kms per year. The small and medium sized company drivers were more likely to drive in excess of 200,000 kilometres per year than were the owner drivers or employee drivers of the large companies. As is shown in Graph 3, 66% of small company drivers and 60% of medium company drivers drove more than 200,000 kilometres per year, compared with 48% of owner drivers and 43% of large company drivers.

The number of kilometres driven annually did not appear to be related to the number of years experience driving large trucks. For example, of those drivers with less than 5 years experience, 80% drove between 100,000 and 300,000 kilometres per year. This suggests that there is not necessarily any "breaking in" period to the industry, in which drivers gradually build up the number of kilometres driven.

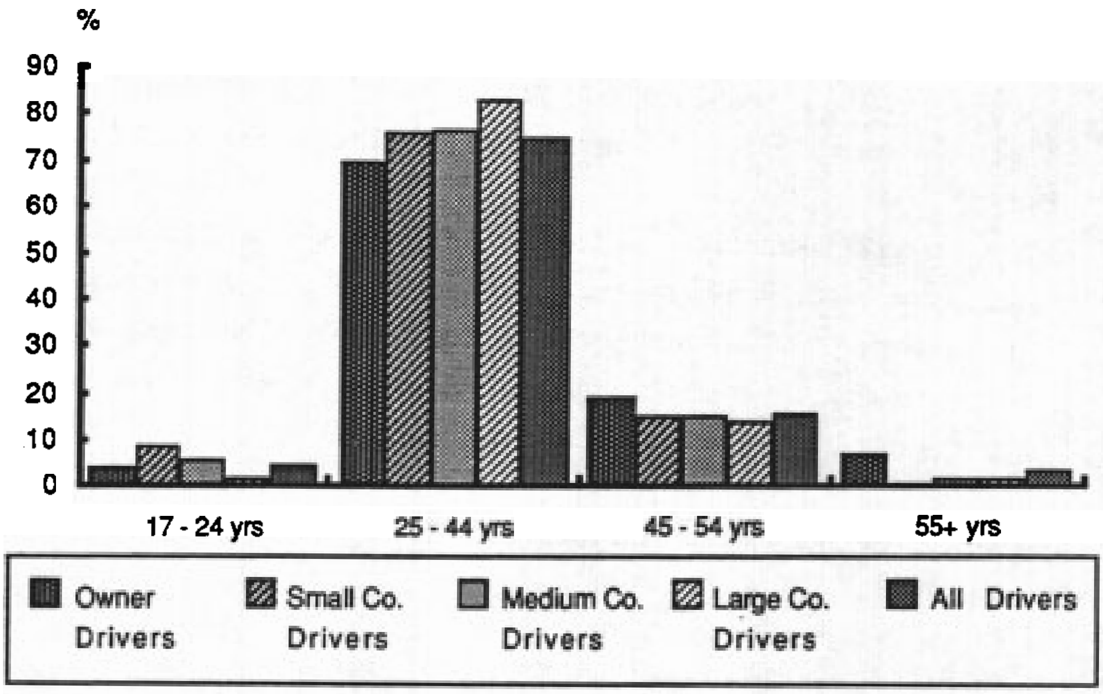
Graph 3 Annual kilometres by type of driver



3.4 Age of drivers

The age distribution of the sample of drivers by type of driver is shown in Graph 4. As is to be expected drivers are concentrated in the middle age brackets, with only a small percentage in the youngest and oldest age brackets; 5% of all drivers were less than 24 years of age and 3.5% over 55 years. The significance of these figures lies only in the fact that they demonstrate that the age distribution of truck drivers is similar to that of the general working population which is contrary to the myth that abounds of the truck driver as a young irresponsible "cowboy".

Graph 4 Age of drivers by type of driver



It is interesting to note here that of the sample of 820 drivers, 5 female drivers were interviewed. However, this sample of female drivers is not large enough to allow disaggregated statistical analysis by sex.

3.5 Previous occupation

Drivers were asked what their previous occupation, if any, was before becoming a truck driver. Of the sample, 25% had always been truck drivers with no previous occupation indicated. A wide range of other occupations were represented by the remainder of the sample. These have been classified into broad occupational groupings. The percentages of the total sample, and for owner and employee drivers, for each of these groupings are shown in Table 3.

A significant proportion of the sample, 30%, had previous experience as trades-persons. Not surprisingly motor mechanics were strongly represented in this group. This was followed by 14% who were unskilled or general labourers, and 10% who were plant and machinery operators. Perhaps surprisingly a further 10% were managers and administrators with 8% previously employed in other professional/para-professional or white collar areas. Overall, about 40% of truck drivers have no experience or skills other than truck driving.

Table 3 Previous occupation

Occupation group	% of owner drivers	% of employee drivers	% of total sample
Managers & administrators	11.6	8.2	9.5
Professionals	2.3	1.6	1.8
Para-professionals	3.2	2.0	2.4
Tradespersons	30.6	29.0	29.6
Clerks	2.9	1.6	2.1
Salespersons	1.3	1.8	1.6
Plant & machinery operators	8.4	11.2	10.1
Labourers & general workers	14.5	13.1	13.7
Armed forces	2.9	2.7	2.8
Always a truck driver	19.7	27.6	24.6

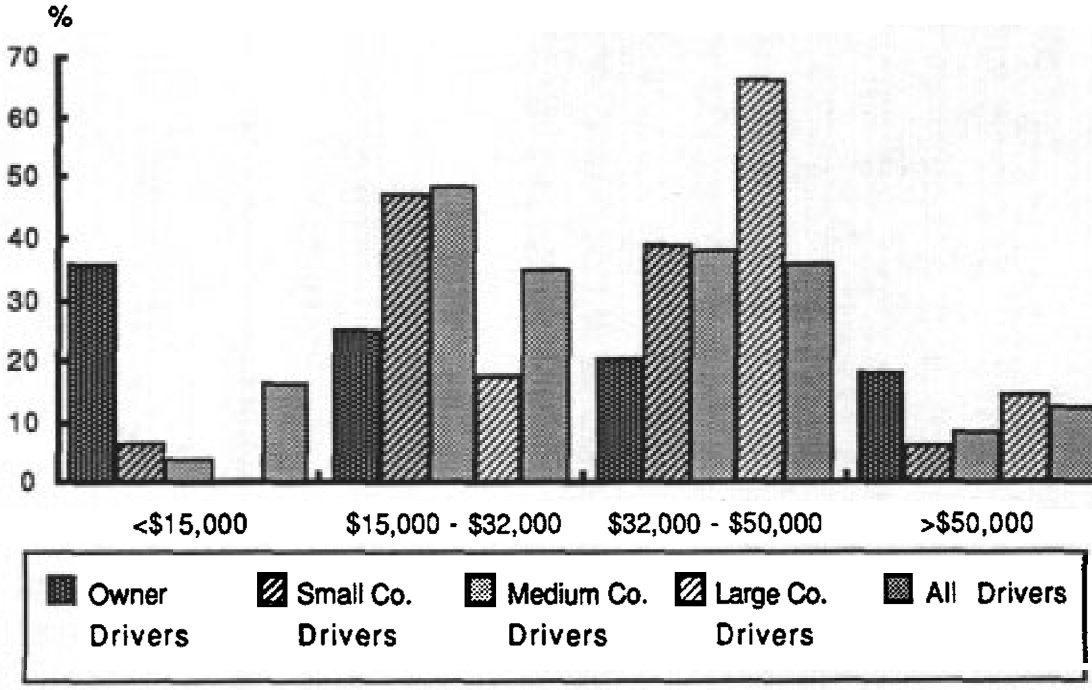
Of owner drivers 20% had always been truck drivers and 18% were unskilled labourers. On the other hand 15% of owner drivers had previous managerial and administration experience. This was slightly higher than for employee drivers where 8% of employee drivers had managerial or administration experience. Over a quarter of fleet owners had been managers, administrators or professionals before entering the truck industry, being double the proportion for other types of drivers. Of employee drivers 28% had always been truck drivers. Of small company drivers 25% were unskilled labourers, 16% of medium company drivers and 12% of large company drivers.

3.6 Income from truck driving

The distribution of income received from truck driving for the financial year 1989-90 for the whole sample is shown in Graph 5. The majority of drivers are concentrated in the range of $15,000 to $50,000 per annum, as would be expected with the dominance of employee drivers in the sample. However the distribution is skewed towards the lower income brackets. When we look at income by type of driver a different picture emerges (see Graph 5).

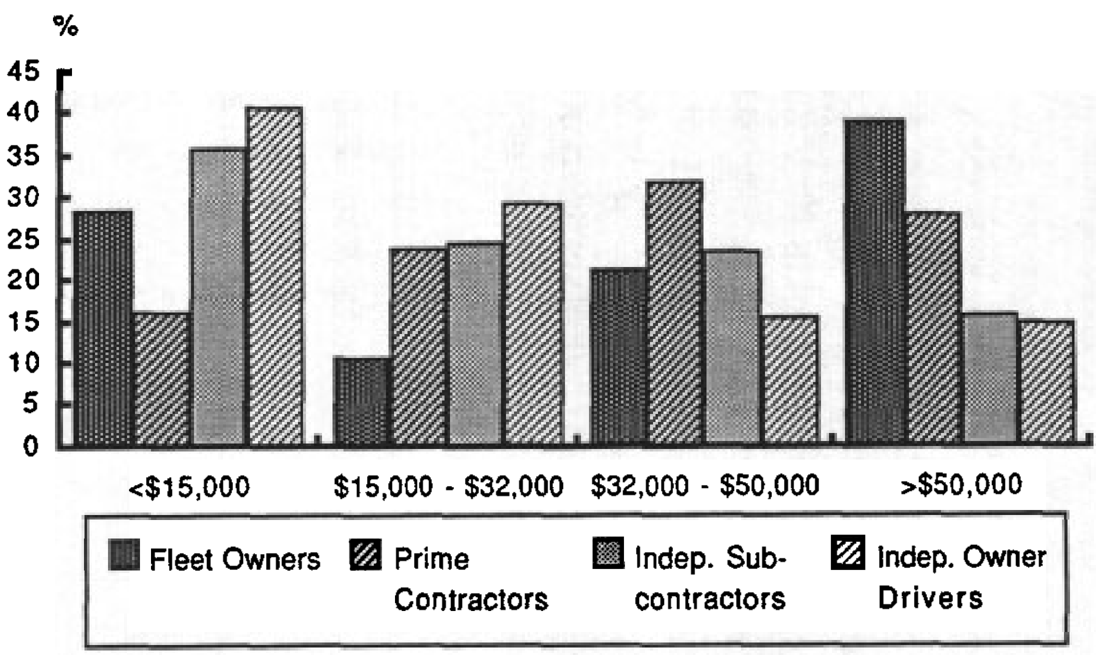
For owner drivers, 36% earned less than $15,000 from truck driving in the financial year 1989-1990 and 26% earned between $15,000 and $32,000. Overall 62% of owner drivers earned less than $32,000 in the financial year 1989-1990, with 50% earning less than $22,000. This compares with 19% of small company employee drivers, 12% of medium company employee drivers and 0% of large company drivers who earned less than $22,000. The majority of employee drivers were found in the middle income ranges of $22,000 to $50,000 but for large company drivers 66% earned between $32,000 and $50,000.

Graph 5 Income from truck driving in 1989-90 by type of driver



The pattern of income by type of owner driver also varies greatly. The distribution of income by type of owner driver is shown in Graph 6.

Graph 6 Income from truck driving in 1989-90 by type of owner driver



A greater proportion of independent owner drivers and independent subcontractors are concentrated in the lower income levels; 36% of independent subcontractors and 41% of independent owner drivers earned less than $15,000. Owner drivers who earn less than $15,000 per annum did not seem to be significantly different from the population of owner drivers or all drivers in general. That is they were not necessarily younger drivers, drivers with less experience or with differing household financial responsibilities.

The income of prime contractors more closely resembled that of employee drivers with 56% earning between $15,000 and $50,000. For fleet owners there seemed to be a much greater range in income earned with 29% earning less than $15,000 and 39% earning over $50,000. The income statistics for fleet owners should be interpreted with some caution, as the income may in some cases have been given for the fleet as a whole, rather than for the driving the owner does himself.

For the majority of drivers the income earned from truck driving was the only income for their household. Sixteen percent of drivers had no other members in their household and for 52% of drivers the other members of their household earned no other income. For those drivers who had other members in their household earning other income, the income in the majority of cases was less than $22,000 per year.

These figures highlight the disparity in economic reward received by owner drivers and employee drivers and also by different types of owner drivers. The average income per annum derived from truck driving found in the sample for each type of driver is shown in Table 4. The reasons behind this and the impact, if any, that it may have on on-road behaviour will be explored in subsequent sections of this report.

Table 5 compares the gross and net average incomes for owner drivers. Gross average income includes the expenses drivers incur whilst truck driving such as fuel, repayments and maintenance. These driving expenses will be examined in more detail in section 4.5.4. Fleet owners have the highest gross income, although their expenses may be for the driving by the driver himself, or for his fleet, or a combination of both. Prime contractors have the lowest average expense rate. Independent owner drivers have the lowest average of net income as percentage of gross income.

Table 6 compares the income statistics found in the sample of drivers with Australian Bureau of Statistics (ABS) data on average weekly earnings for full time non-managerial employees by occupation category. We have used the ABS figures for male income only as it is more meaningful in relation to our sample (out of 820 drivers only 5 were female).

Table 4 Average income for the financial year 1989-90 by type of driver

Type of driver	Average Income	Standard Deviation	Median Income
All drivers	$32,568	$19,314	$22K - $32K
Owner drivers	$29,698	$27,098	$15K - $22K
Fleet owners	$45,958	$36,288	$32K - $52K
Prime contractors	$39,841	$25,444	$32K - $52K
Independent subcontractors	$28,428	$24,729	$15K - $22K
Independent owner drivers	$26,023	$26,045	$15K - $22K
Employee drivers	$34,274	$12,316	$32K - $52K
Small company drivers	$31,374	$12,979	$22K - $32K
Medium company drivers	$33,168	$12,178	$22K - $32K
Large company drivers	$40,322	$9,070	$32K - $52K

Note: Statistics refer to income after truck-related expenses incurred by the driver, but before tax.

Table 5 Gross and net average income for owner drivers

Type of owner driver	Gross average income	Net average income	Net as a % of gross income
All owner drivers	$155,156	$29,698	19
Fleet owners	$207,009	$45,958	22
Prime contractors	$132,400	$39,841	30
Independent subcontractors	$152,109	$28,428	19
Independent owner drivers	$151,897	$26,023	17

Table 6 Average weekly earnings for full-time male non-managerial employees

Occupation	Av. male weekly earnings	Hours
ABS Occupation Categories (May 1990)		
Professionals	$707.40	38.3
Para-professionals	$660.60	39.8
Tradespersons	$563.10	41.4
Clerks	$530.40	39.1
Salespersons	$533.10	39.9
Plant & machinery operators (includes truck drivers)	$577.90	43.3
- truck drivers	$521.50	43.4
Labourers	$494.50	41.6
All Categories	$574.80	41.2
Our Sample (October 1990)		
Owner Drivers	$571.12	
Fleet owners	$883.81	
Prime contractors	$766.17	
Independent subcontractors	$546.69	
Independent owner drivers	$500.44	
Employee Drivers	$659.10	
Small company	$603.35	
Medium company	$637.85	
Large company	$775.42	
All Drivers	$626.31	

Source: May 1990 Distribution and composition of employee earnings and hours Australia, ABS 1991.

ABS data indicate the average weekly income for all occupation categories is $574.80. According to the ABS, full-time male non-managerial truck drivers have an average income of $521.50 per week compared to $626.31 for all truck drivers in our sample. However, there is significant variation in income for the various types of truck drivers in our sample. Fleet owners had the highest average weekly earnings of $883.81 which was significantly higher than the ABS average, though as mentioned earlier, this may reflect the income for the fleet rather than the income of the driver. Large company drivers and prime contractors also had an average weekly income (of $775.42 and $766.17 respectively), well above the ABS average for truck drivers. Independent owner drivers were the only type of driver in our sample to receive a weekly income lower than the ABS mean income for truck drivers ($500.44 compared to $521.50).

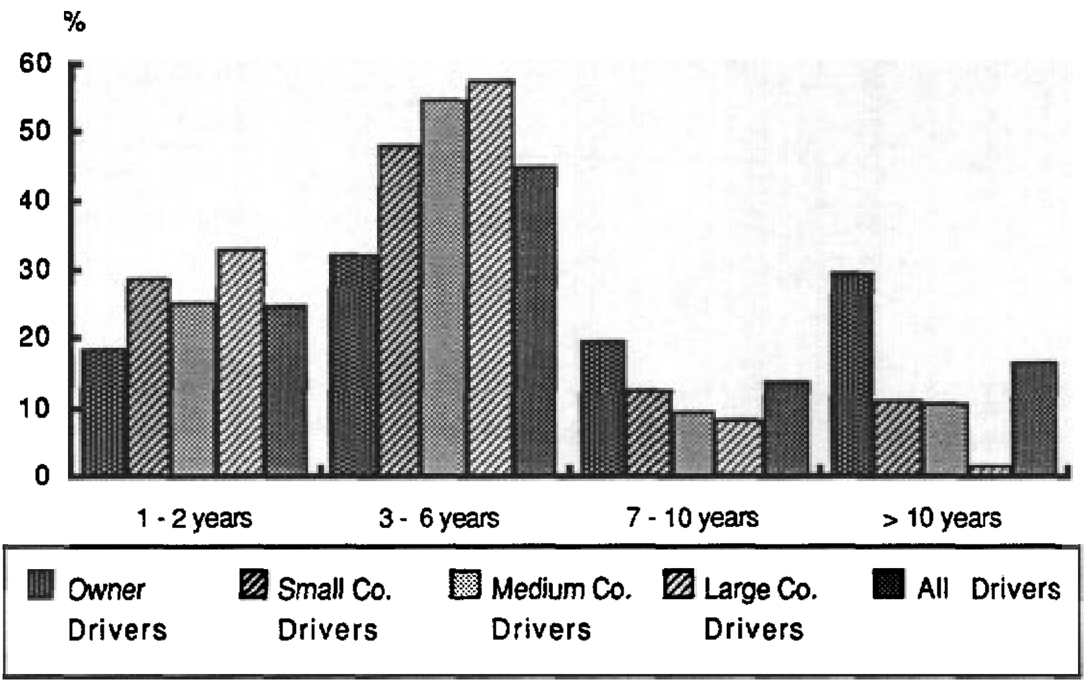
It must be noted that the ABS data for truck drivers do not differentiate between long distance and short distance drivers. The income structure of the two distance sectors is likely to be very different. The average working week of 43.4 hours reported in the ABS data is much shorter than that found in the sample and again probably reflects the influence of the short distance sector.

3.7 Age of trucks

A commonly accepted anecdote of the trucking industry is that there are two classes of owner driver: those that drive old badly maintained vehicles and those that invest in the latest most expensive rigs. From our survey we found some evidence to support the "old truck" theory. Owner drivers were more likely to be driving a second hand vehicle which was considerably older than those driven by employee drivers, especially those employed by the large companies.

The distribution of the age of the trucks by type of driver is shown in Graph 7.

Graph 7 Age of trucks by type of driver



For the total sample 24.6% of trucks were 1 or 2 years old and 83.5% were up to 10 years old. The large companies were most likely to have the newest fleet. The average age of a truck for the types of drivers in the sample is shown in Table 7. Sixty percent of large company trucks were less than 3 years old compared with around 45% for small and medium sized companies and 20% for owner drivers.

Table 7 Average age of truck by type of driver

Type of driver	Average age of truck
Owner drivers	
Fleet owners	5.0 years
Prime contractors	7.8 years
Independent subcontractors	8.0 years
Independent owner drivers	7.9 years
Employee drivers	
Small company drivers	5.2 years
Medium company drivers	5.2 years
Large company drivers	3.9 years

4. FACTORS INFLUENCING ECONOMIC REWARD

The aim of this study is to explore the linkages, if any, between economic reward and the on-road behaviour of long distance truck drivers. To fully explain the impact of a range of factors relating to economic reward and on-road behaviour an econometric model was developed and results will be discussed in Section 6. However we can begin to determine some of the factors which may impact on economic reward and thus would warrant further exploration in the modelling analysis by undertaking a basic descriptive analysis of the data.

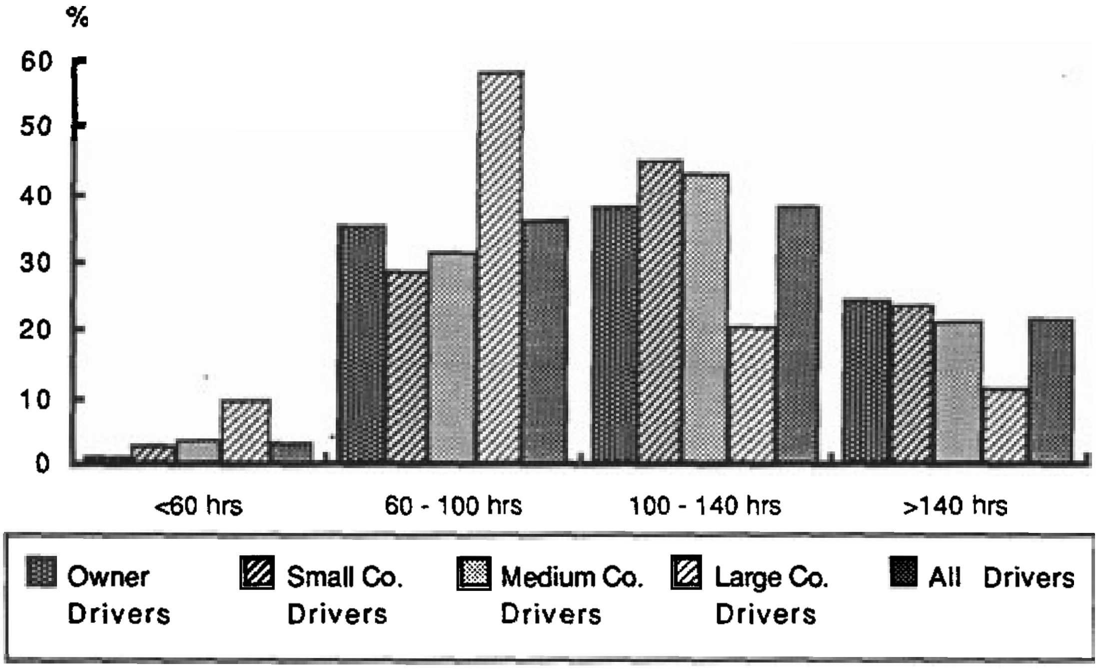
The pre-pilot and pilot interviews with drivers revealed a lifestyle and a working routine dictated by organising loads, schedule requirements, the opening hours of loading/unloading depots, long hours of loading/unloading and driving, long unproductive hours of waiting for loads, and for owner drivers financing their vehicles. The main survey collected data on these issues which provided input to the econometric model. In this section of the report we will look at these items in a purely descriptive sense to gain some understanding of the factors which influence the economic reward received by drivers. Factors which are a constraint on economic reward influence, in an indirect way, the work practices which the driver adopts to remain economically viable. It is possible that some work practices may impinge on the margin of safety that the driver allows himself on the road. That is, due to economic pressures, the driver is continually pushing himself into the fatigue zone by working (driving and/or loading) long hours, attempting to shorten his trip time by increasing speed and reducing stop time and relying on stimulant drugs to maintain alertness.

4.1 Productive and non-productive time

Drivers were asked how many hours a week they spent earning a living as a truck driver. These hours include all activities undertaken in order to earn a living from truck driving. As well as actual driving time, drivers are also often responsible for loading and unloading their truck, organising the load, and repairs and maintenance on the truck. The hours ranged from 20 hours per week to 168 hours per week, with an average for the total sample of 105 hours per week. Some drivers, particularly owner drivers considered that they worked a 24 hour day up to 7 days per week. Even when they were not driving or loading they felt that they were "on duty" waiting for loads, snatching sleep in their truck whenever they could. Twenty-two percent of the sample said that they worked 140 hours or more per week and only 4% of the sample considered that they worked less than 60 hours per week.

The distribution of hours worked per week was very similar for owner drivers and for employee drivers of small and medium sized companies. However amongst larger company employee drivers the majority of drivers worked between 60 and 100 hours per week, but 24% of large company employee drivers still worked over 120 hours per week. Unlike owner drivers, employee drivers, particularly of large companies, are more likely to be paid overtime rates for driving long hours. The distribution of hours worked by type of driver is shown in Graph 8.

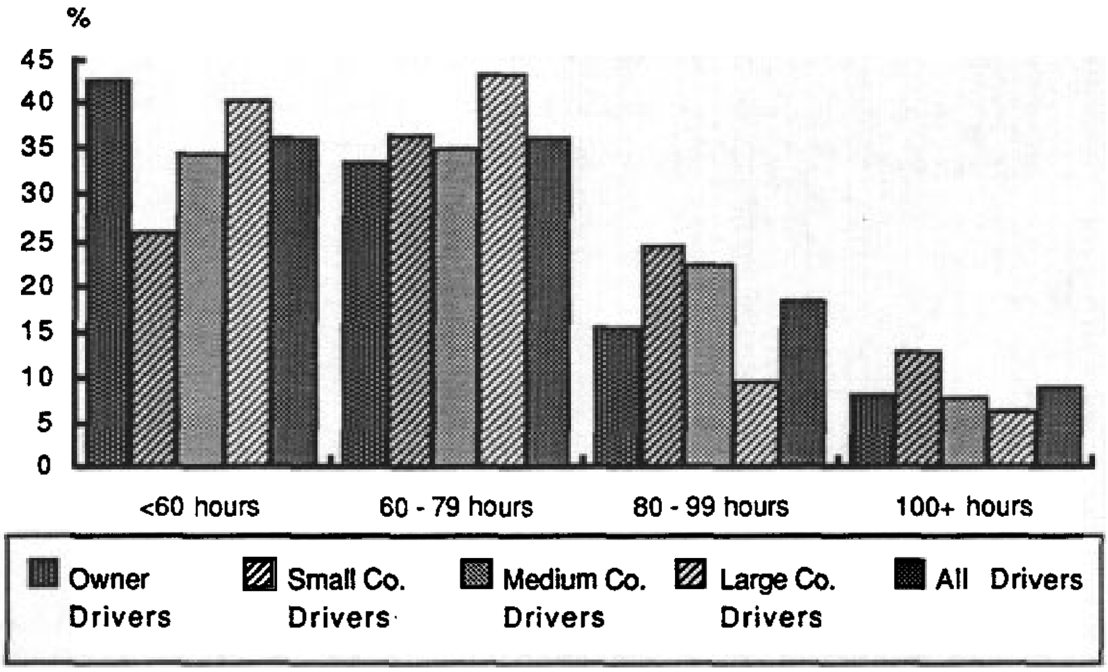
Graph 8 Number of hours worked per week by type of driver



Drivers were also asked to estimate the percentage of total work hours they spent driving. The percentage of hours spent driving ranged from 14% to 100%, with an average of 65%. Employee drivers spend on average 67% of their work time driving, rising to 71% for large company employees, whilst for owner drivers the mean is 61%. This is because the large companies have loading and unloading staff and maintenance workers at depots who prepare the truck for the driver, thus taking a lot of the pressure off the driver by reducing his working time and thus fatigue levels.

Actual driving hours by driver type are shown in Graph 9. The average driving hours per week for all drivers is 67 hours. Nearly 10% of drivers spend at least 100 hours a week driving a truck, with the figure rising to 13% for small company drivers and falling to 6.6% for large company drivers. Small company drivers drive the longest hours per week (average of 72 hours), and large company drivers the least (average of 61 hours). Owner drivers have the highest proportion in the less than 60 hours per week category (42.6%), closely followed by large company drivers (40.2%).

Graph 9 Number of hours driving per week by type of driver



It may be reasonable to expect that increased working hours would lead to increased income for the driver. However there appears to be a marked variation in the productivity of various work activities in the trucking industry. This is illustrated by the fact that drivers with longer total working weeks did not earn substantially higher than average incomes. Of those drivers working over 140 hours a week, only 6.4% earned over $60,000 per annum, compared to 5.3% for all drivers. In fact, 12.9% of drivers working over 140 hours per week earned less than $9,000 net, compared to 8.8% of all drivers. On the other hand, drivers who spent over 100 hours per week driving had a higher average income compared to the rest of the sample. Of those who drive for more than 100 hours a week, 12.3% earned over $60,000 per annum, compared to 5.3% of the whole sample.

The role of productive and un-productive work time in relation to on-road performance is discussed in the econometric modelling analysis in Section 6.

4.1.1 *Time spent waiting to load or unload*

As indicated in the previous section, actual hours spent driving the truck account for only a portion of the driver's work time. Particularly owner drivers, but also smaller company drivers, have to spend time and expend physical effort loading and unloading the truck and waiting around so that these activities can be arranged. Undertaking these other functions before and after a long distance trip most certainly adds to the general level of stress and fatigue under which the driver continually operates. He becomes caught up in a cycle of loading - driving - unloading with very little chance to obtain adequate rest.

The involvement of the driver in these other activities is often overlooked when considering potential fatigue levels and the implications for the safety of the road environment. It is also overlooked when determining the economic return to the driver. This non-driving time is unproductive time in that freight rates paid or rates paid to employee drivers are related to the distance of the route. Even if employee drivers are paid hourly, rates are usually based on the driving time between origin and destination. As stated previously, increased work time did not necessarily result in increased income.

Evidence emerged from the pilot survey which indicated that the opening hours and operating practices of loading depots and factories were also important influences on the workload of the driver either before or after his trip. It was not uncommon to hear reports of drivers being held up waiting to load or unload either because the depot was not open, or for some reason there was a delay before his truck could be attended to. It also became evident from the discussions with drivers in the pilot survey that, even if drivers were not forced to meet a scheduled time of arrival set by the freight owners, they aimed to arrive at their destination as soon as possible in order to be first in line to unload and/or to arrange their next load. We found striving for a "place in the queue" was a more powerful source of competition in the industry than open price competition for freight.

At the end of the designated trip for each driver in the survey, 34% said that the depot was not open when they arrived. However 90% of these drivers did not see this as a problem. They took the opportunity, having arrived and secured their place in the unloading queue, to catch up on some sleep. Once the depot was open 30% of drivers reported delays in being able to unload. The main reasons cited for the delays were being held up in a long queue of trucks which arrived before them (42%), inefficient staff at the unloading depot or the machinery was not available (32%), or waiting while local trucks were unloaded (17%).

Overall 25% of drivers had to wait more than an hour before they could unload. Unloading time for the majority of drivers was between 1 and 4 hours (52% of drivers), with 45% of drivers unloaded within an hour. These figures indicate that on the particular trip sampled in the survey over half the drivers spent between 1 and 4 hours after completing their trip unloading or waiting while the cargo was unloaded. In addition some of these drivers spent time waiting before they could unload. Many drivers also reported after unloading having to undertake other activities such as returning empty pallets, refuelling which can take up to half an hour for a vehicle that size, washing the truck, and carrying out repairs and maintenance of the truck.

4.2 Contracts for loads

The availability of loads and the certainty of supply of loads is important in determining the economic prospects, at least in the short term, for the driver and the company. For those owner drivers who have no contracts or regular arrangements for loads their economic existence, particularly at times when freight is scarce, is precarious. Twenty-two percent of the drivers in the sample indicated that there were no regular contracts for their loads, 32% had contracts for all their loads, while 43% had contracts for at least some of the loads. Over 80% of drivers for medium and large companies indicated that there were contracts for at least some of their loads, while on the other hand 32% of owner drivers had no contracts for any loads. Fifty percent of small company drivers had contracts for some of the loads only. By definition the prime contractor was most likely to have at least some loads covered by a regular contractor. The fleet owner also had at least some loads covered by contract, whereas the independent owner driver was least likely to have contracts for his loads.

Of those drivers who did not have a contract arrangement for any of their loads, 76% claimed that they usually organised another load in less than 24 hours. It must be remembered that this figure is susceptible to changes in the conditions of the supply of freight. At the time of this survey (September - October 1990) there were indications from drivers towards the end of the interviewing period that it was becoming increasingly difficult to arrange loads as the economic downturn was starting to impact on the supply of freight.

4.2.1 Contracts for backloads

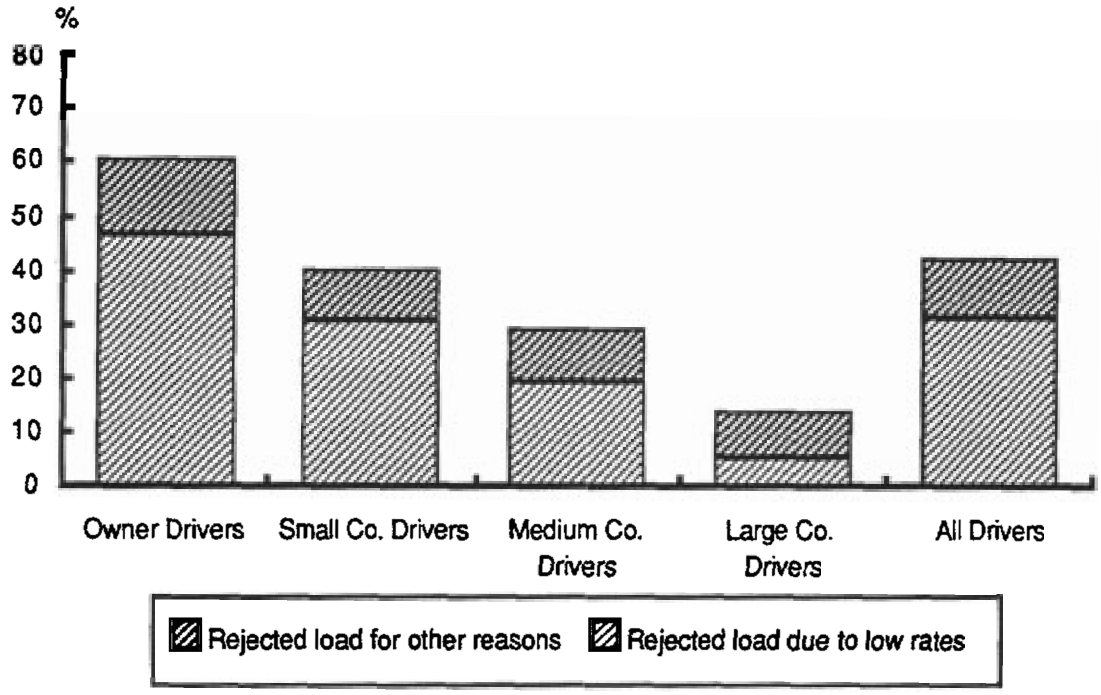
Another important consideration is the arrangements for the backload. Even if a regular contract is available for a forward load, it is reduced in value if there is no guarantee that there will be an economically viable load on the return trip. This is particularly the case to some destinations, such as Perth and Brisbane where the flow of freight out of these centres is much lower than the flow of freight to these destinations. Thus competition for backloading out of these centres often pushes rates below the operating cost of the trip. As a result some drivers do not accept loads to these destinations, particularly in times of tight freight supply, while others prefer to return empty cutting their losses in terms of fuel consumption but not expending time and effort loading and unloading cargo which is not covering the cost of the trip. Other drivers do accept loads at less than cost thus depressing rates further on these routes.

Of all drivers, 36% had either no arrangements in the forward load contract, or no other contract, to cover the backload leg of a forward load contract.

4.3 Rejection of loads

Even if loads were available, on occasions drivers rejected loads for a number of reasons. Over 40% of drivers had rejected a load within the last 12 months. As would be expected, the rejection rate was higher amongst owner drivers (61% had rejected a load) than amongst company drivers (31%), as shown in Graph 10. The rate of rejection amongst company drivers varied considerably with 40% of small company drivers having rejected a load, but only 14% of large company drivers. Amongst owner drivers, prime contractors were least likely to have rejected a load, although 52% had done so in the last 12 months.

Graph 10 Percent of drivers who rejected load in last 12 months



The main reason given for rejecting a load was that the freight rate was too low. Over 30% of all drivers in the sample had rejected a load in the last 12 months due to low rates (see Graph 10). Fifty-two percent of independent owner drivers and 47% of independent subcontractors had rejected a load due to low rates in the last 12 months. In contrast, only 6% of all large company drivers and 20% of all medium company drivers had rejected a load due to low rates. Generally the smaller, more independent the operation the greater the likelihood of rejection due to low rates. Of the 60% of drivers who had rejected a load, 73.5% mentioned low rates as a reason, varying from 85% of independent owner drivers to only 40% of large company drivers.

Drivers who had rejected a load because the rate was too low were asked to indicate the rate which was offered and the minimum rate necessary to induce the driver to accept the load. On average the offered rate was 25% below the minimum rate which the driver would accept. The differential between offered and minimum acceptable rates did not vary substantially by driver type or by method of payment.

The most common origins of low rate trips were Brisbane (33%) and Sydney (28%), followed by Perth (11%) and Melbourne (9%). The greatest difference between the offered and minimum acceptable rate was for trips originating in Perth. On average for the 26 trips originating in Perth, the offered rate was two-thirds of the minimum acceptable rate. The offered rate on trips from Brisbane was also lower than the average of 75% of the minimum acceptable rate. For trips from Sydney, Wollongong, Newcastle, Melbourne and the rest of Victoria, offered rates were at least 80% of the minimum acceptable rate. The most common destination to which low rates were offered was Melbourne (35%), followed by Sydney (24%) and Brisbane (20%) and also Adelaide (9%). The destination of the trip did not have as marked an influence on the differential between offered and minimum acceptable rates as did the trip origin.

The other main reasons given for rejecting loads were that the customer was known to be unreliable in paying his account (7.4%), the driver already had a load (5.7%), getting a backload from the destination was difficult (5.1%) and the load was overweight (4.5%). Nine drivers (2.7%), including 6 owner drivers, also refused a load because it would require exceeding legal driving time.

4.4 Operating expenses for owner drivers

Owner drivers only were asked a series of questions regarding the operating expenses of their current truck including purchase date, purchase price, financing arrangements, repayments and details of other running expenses.

4.4.1 *Cost of trucks*

The purchase price, plus on-road costs, of the trucks owned by drivers in the sample ranged from $5,000 to $370,000, with an average price of $107,771. Ninety percent of drivers owned trucks which they purchased for less than $200,000. This figure reflects the high proportion of second hand vehicles purchased (63% of vehicles were second-hand). All types of owner driver, with the exception of fleet owners, were more likely to have a second hand rather than a new truck. Two thirds (65%) of owner drivers had trucks which they purchased in 1988 or later (the survey was conducted in late 1990) thus they had owned them for 2 years or less. Twenty-five percent had purchased their truck between 1985 and 1988.

4.4.2 **Financing the truck**

Given the substantial investment required to purchase a truck (an average price paid of around $100,000 was found for the sample) it is not surprising that the majority (79%) of owner drivers who had borrowed money or leased their truck were paying off their truck at the time of interview. Leasing a truck was a more popular option amongst fleet owners (25%) compared to prime contractors (20%), independent subcontractors (18.4%) and independent owner drivers (11.9%).

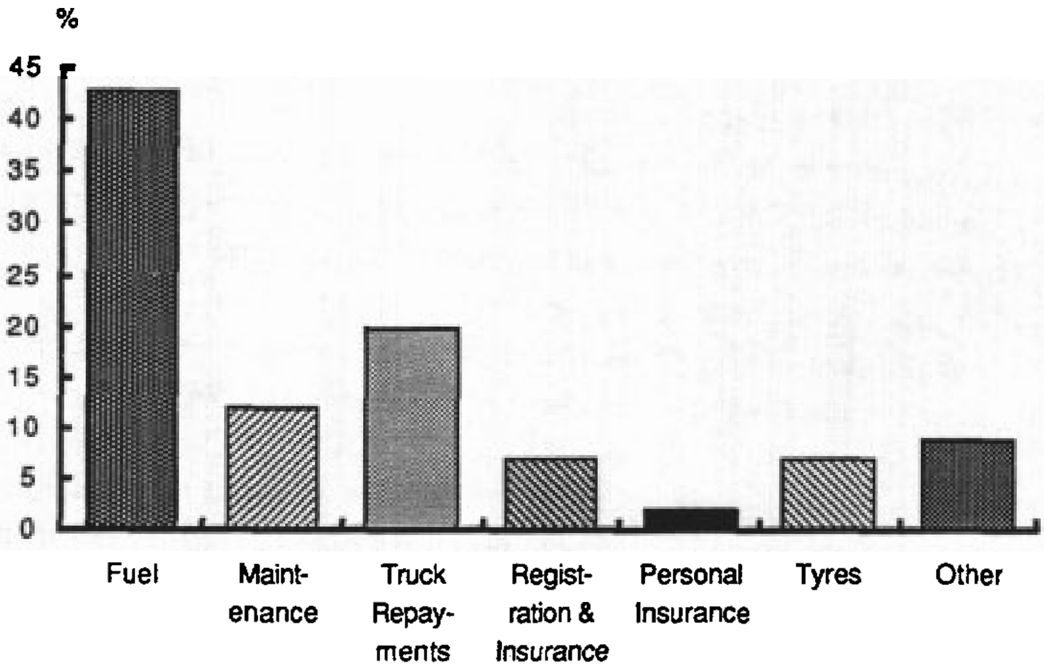
What perhaps is a concern is firstly, the low level of deposit which some drivers put down on the purchase, and secondly, the generally short term of the loan resulting in a steep repayment structure. Under these conditions drivers are continually pressed just to earn sufficient income to meet the high level of repayments on their vehicle. Twenty-seven percent of drivers who had borrowed money to purchase their truck had less than $5,000 deposit. The period of the loan ranged from 1 to 8 years, with an average period of 4.25 years and 97% of loans being for 5 years or less. All repayments were on a monthly basis and ranged from $180 per month to $8000 per month, with an average monthly repayment of $2,449. Fifty-seven percent of loans required repayments of between $1,000 and $3,000 per month. We found truck repayments to be unrelated to work hours or trips undertaken.

The majority of loans (64%) were arranged with a finance company and 32% were with banks. It is reported to be very easy for truck drivers to arrange loans with finance companies, which require very low deposits and are not particularly diligent in establishing the ability of the driver to meet the loan commitments. In return, they charge interest rates considerably higher than the major banks.

4.4.3 Running expenses

In addition to the high financing costs of their vehicles, owner drivers are continually faced with the high running costs of the vehicle in order to make a living. The average total running expenses for all owner drivers in the sample was $123,543 per annum. The major cost items were fuel average of $60,914, repayments on the truck $27,741, maintenance $16,922 and tyres $10,359. The distribution of the average cost for each of these items as a percentage of average total cost is shown in Graph 11.

Graph 11 Expenses of owner drivers as a percentage of total expenses



4.5 Method of payment for employee drivers

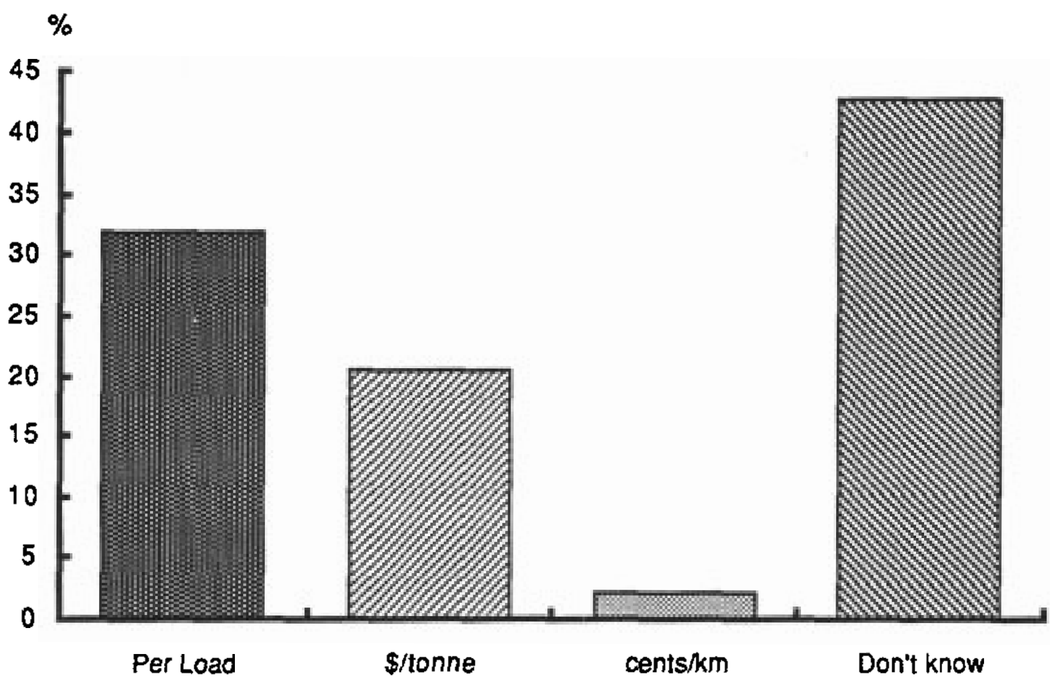
Employee drivers are paid in a number of ways. These include a fixed salary, percentage of the truck earnings, paid by the trip, paid at an hourly rate, or some combination of these methods. The survey found that 64% of employee drivers were paid by the trip and 15% were paid a fixed salary. If other methods such as paid a percentage of the truck earnings (9.2%) and salary plus trip money (5.7%) are included, 79% are paid in relation to the work load of the truck.

These forms of incentive payments suggest that the more trips a driver is able to complete the greater his earning rate. Thus there is likely to be economic pressure on the driver to complete a trip as quickly as possible and to undertake as many trips as possible. It is likely then that this incentive to increase earning capacity by being paid by the trip could have implications for the behaviour of the driver on the road. Thus although an employee driver, unlike the owner driver, may have the surety of employment, using the payment mechanism of being paid by the trip, gives him the incentive to increase his earning capacity by increasing the amount of work undertaken. Thus in this sense there may be little difference between the economic pressures behind the employee driver and the owner driver which may impinge on the safety of the road environment. These hypotheses will be explored further in Section 6 of this report.

4.6 Analysis of freight rates

The rate which a driver receives for a load obviously influences the economic viability of each trip and in the long run the economic viability of his business if he is an owner driver or his prospects for employment depending on the economic health and stability of the company if he is a company driver. For each of the trips in the survey we obtained the rate paid for the freight being carried on that trip. Almost a third of all freight was paid for by the load while 20% was paid for per tonne of freight carried. Several drivers said that the freight was paid for by the kilometre. Over 40% of drivers did not know the freight rate for the trip (see Graph 12).

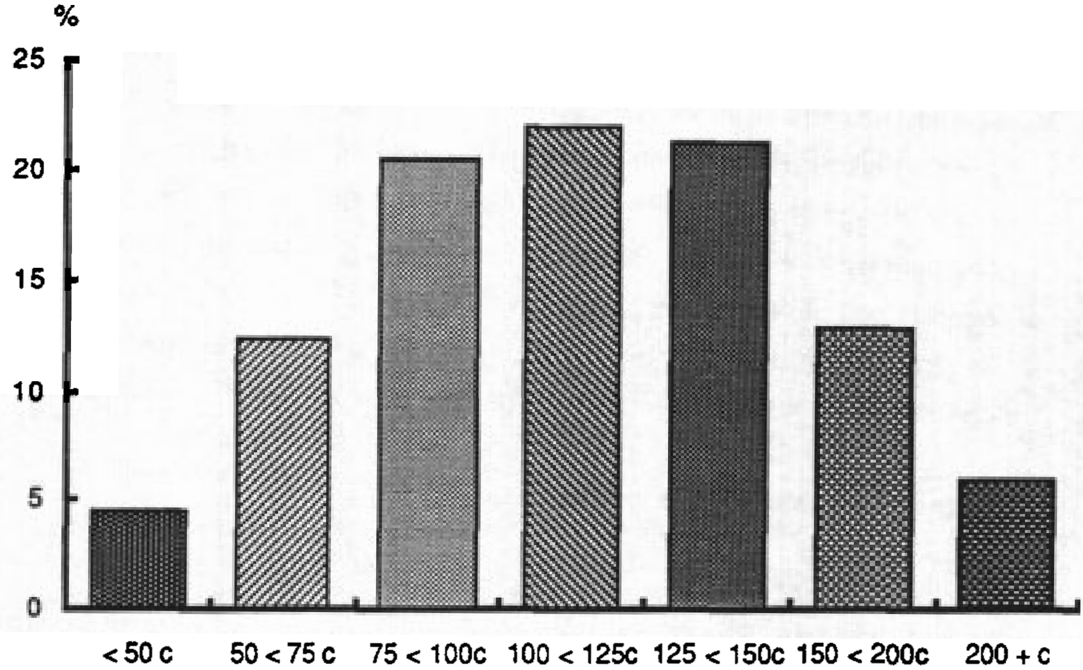
Graph 12 Method of payment for freight



Owner drivers were more likely to know the rate and type of payment for the trip, with only 7% not knowing the rate. Almost two-thirds of company drivers did not know the freight rate received by their employer for the sampled trip.

To compare freight rates for the trips, all methods of payment (per hour, per tonne, per load, per km) were converted into a rate of cents per km travelled. The total rate for the designated trip was calculated and divided by the length of the trip in kilometres to obtain a trip freight rate expressed in cents per km. The mean rate was 122.5 cents/km ($1.23/km). A frequency distribution of the rate is shown below in Graph 13.

Graph 13 Freight rates (cents per kilometre)



Characteristics of trips which may explain rates are summarised in Table 8. It is difficult to analyse freight rates by driver type due to the different proportion of each type of driver in the "don't know" rate category. Because a higher proportion of company drivers did not know the freight rate received by their employer for the trip, owner drivers were over-represented in every rate class while company drivers were generally under-represented in each class (see Table 8). The average rate received was $1.23/km. Amongst owner drivers, prime contractors received the highest rate of $1.32/km. There were large differences in the rates received by size of company: medium companies received an average of $1.60/km while large companies received just $1.04/km. However this difference must be treated with caution as many large company drivers did not know the trip payment received by their employer, resulting in a small sample.

Rates did not vary substantially by cargo type (Table 8). Rates for general cargo loads were slightly higher than the mean while perishable cargo rates were a few cents lower than the average rate. Rates for mixed loads or dangerous goods were lower, but again there is the problem of sample size as there were few trips with cargos in these categories.

Table 8 Selected trip characteristics and freight rates

Characteristic of trip	Rate / km	No. of trips
AVERAGE - ALL TRIPS	$ 1.23	(435)
Owner drivers	$ 1.18	(270)
Employee drivers	$ 1.30	(165)
Perishable cargo	$ 1.18	(102)
General cargo	$ 1.25	(318)
Mixed cargo	$ 1.07	(13)
Articulated truck	$ 1.17	(373)
Road train	$ 3.32	(8)
Car/boat trailer	$ 1.80	(8)
Employer organised load	$ 1.40	(113)
Freight forwarder one-off	$ 1.15	(115)
Freight forwarder preferential	$ 1.09	(65)
Load considered forward load	$ 1.27	(203)
Load considered backload	$ 0.94	(76)
Trips out of Sydney	$ 1.41	(56)
Trips into Sydney	$ 1.20	(215)
Trips between Syd-Melb-Bris	$ 1.20	(171)
NSW intrastate trips	$ 1.97	(31)
Adelaide, Perth to Sydney trips	$ 0.71	(23)

Note: Care should be taken in the interpretation of some of these results due to small sample sizes.

Rates were also analysed by type of truck. However, as most trucks in the sample were articulated (83%), there was a problem of sample size when analysing truck type. However the rates for specialised types of carriers were higher than average. The road train rate was two and a half times the average while the car/boat trailer rate was one and a half times the average rate (see Table 8).

From Table 8 we can see that the highest freight rates were associated with employer-organised loads while lower than average rates were associated with one-off freight forwarder deals or deals where freight forwarders gave the respondent preferential treatment in offering the driver the load ahead of other competing drivers.

Loads considered to be forward loads were paid at the above average rate of $1.27/km which was approximately a third more than the rate for backloads (94c/km).

Rates were also analysed by type of route (Table 9).

Table 9 Rates on selected routes (in order)

Origin	-> Destination	Rate / km	No. of trips
Sydney	-> Woll./N'castle	$ 2.61	(8)
Rest of NSW	-> Sydney	$ 1.70	(17)
Rest of VIC	-> Sydney	$ 1.34	(30)
Melbourne	-> Sydney	$ 1.34	(77)
Melbourne	-> Brisbane	$ 1.25	(15)
Sydney	-> Brisbane	$ 1.21	(31)
Sydney	-> Melbourne	$ 1.03	(14)
Rest of QLD	-> Sydney	$ 1.00	(31)
Brisbane	-> Sydney	$ 0.96	(34)
Adelaide	-> Sydney	$ 0.76	(14)
Perth	-> Sydney	$ 0.64	(9)

Note: Other capital city routes have been excluded from the table due to small sample size.

One of the shortest routes (rest of NSW to Sydney) has the highest rate per km while the longest route (Perth to Sydney) has the lowest rate per km. Trips from Victoria (including Melbourne) to Sydney have higher rates than trips from Queensland (including Brisbane) to Sydney.

It appears that NSW intrastate routes have the highest rates: the Sydney to Wollongong/Newcastle rate of $2.61/km (based on 8 trips) is particularly high. Of interstate routes, trips originating from Melbourne and the rest of Victoria have the highest rates. Interestingly, rates for interstate trips appear to be related to direction as Melbourne to Sydney trips and Sydney to Brisbane trips had substantially higher rates than the corresponding southbound trips Sydney to Melbourne and Brisbane to Sydney. Rates for trips from the smaller capital cities Perth and Adelaide to Sydney were considerably lower than rates for other trips.

4.7 Main issues facing the industry

Concern about economic conditions was reflected in the comments made by drivers about the main issues facing the industry. The most commonly reported major issues stated by drivers are listed in Table 10.

Table 10 Most frequently stated important issues facing the industry

Important issues facing the industry	% of issues mentioned
Freight rates	
Freight rates should be increased and standardised	26.3
Freight rates too low in relation to costs	21.8
Too much undercutting of rates	10.4
High level of costs	
Fuel prices too high/no compensation	25.9
All government taxes too high/revenue raising	9.7
High running costs	4.0
Registration fee too high	3.5
Cost of truck maintenance too high	1.6
Interest rates crippling the industry	0.6
General economic conditions	
The recession/hard to get work/lack of freight	7.7
Returns for effort and costs too high	1.9
Drivers' pay too low	1.8
The long hours to make a living	1.5
Other issues	
Poor conditions of roads/should be better maintained	9.0
Police harassment/revenue raising	7.1

5. EXPOSURE TO RISK

The impetus for this study began with the concern about public safety on the road. A number of studies have shown that speed and fatigue are major factors in heavy vehicle crashes. This study is designed to test the hypothesis that speed and driver fatigue are strongly linked to the underlying economic conditions in the long distance trucking industry. This section of the report focuses on a descriptive analysis of the responses in the survey which are indicators of driver behaviour on the road. These include propensity to speed, the possible incidence of fatigue as a result of a strenuous, physically demanding work routine and involvement in crashes. The emphasis here is on describing the responses found in the survey. Conclusive evidence of the links between on-road performance of the long distance truck driver and underlying conditions in the industry cannot be drawn from this analysis. However it is valuable in providing an indication of the factors which will be explored more fully in the econometric models in Section 6.

5.1 Speed

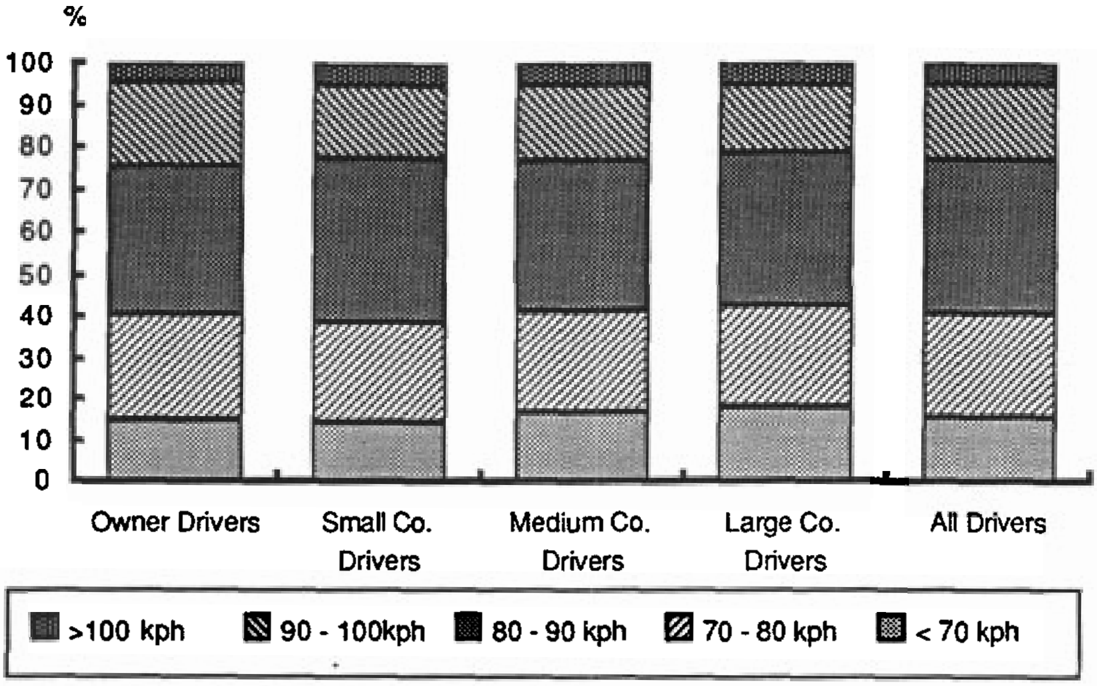
5.1.1 Speed on the sampled trip

The central feature of the survey instrument was the collection from each driver of the details of a specific trip. This was usually the last one-way trip completed by the driver. Details were collected about the activities undertaken before and after the trip, and the time, place, length and reason for each stop on the trip. This approach was used to obtain the information necessary to assess the actual conditions faced by drivers on the road in order to identify associations between the dimensions of speed, economic conditions, and scheduling and other, either self or externally imposed, time constraints.

The average speed of the driver's trip was calculated for the specific trip by dividing the total kilometres of the trip by the driving time for the trip. The mean speed for the whole sample was 81.06 kph. The average speed for each driver type was: large company drivers 79.81 kph, medium company drivers 80.92 kph, owner drivers 81.01 kph and small company drivers 82.01 kph. Graph 14 shows the distribution of the average speed of the trip by type of driver.

As would be expected from the averages, all driver types predominantly travel between 80 and 90 kph. The legal speed limit for trucks is 90 kph and 100 kph for speed limited vehicles. Five percent of small company drivers have an average speed for the specific trip of over 100 kph, compared to 4.9% for large company drivers, 4.8% for medium company drivers and 4.5% for owner drivers.

Graph 14 Average speed of trip by type of driver



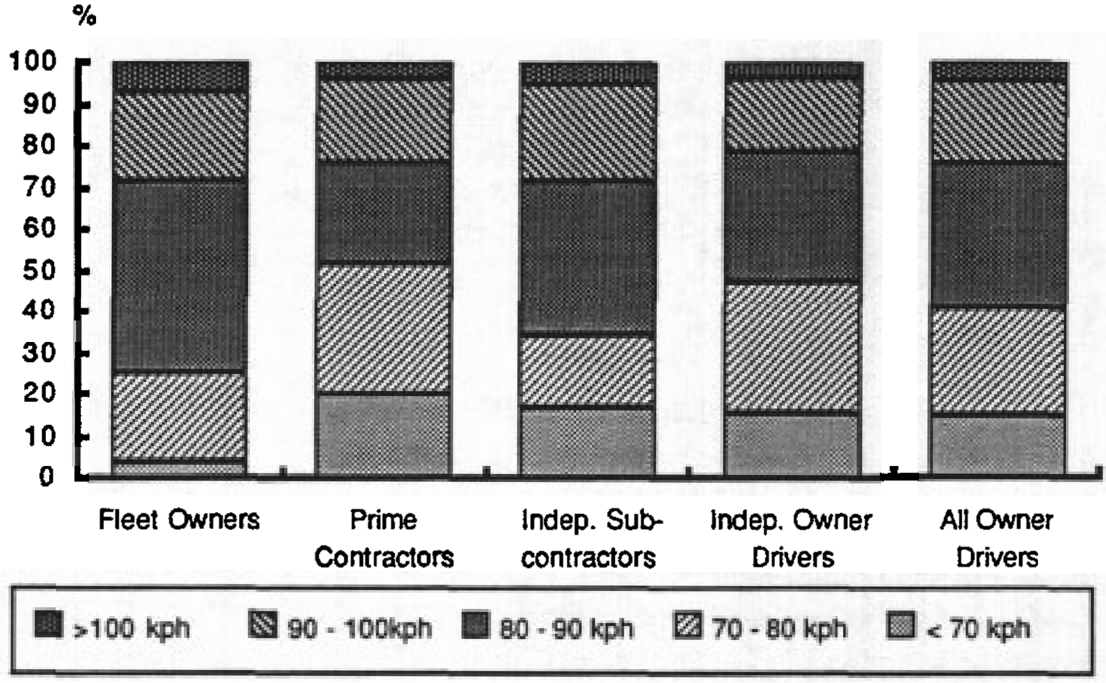
Large company drivers have the largest proportion of drivers in the under 70 kph category (18.1%), followed by medium company drivers (16.5%), and owner drivers (15.1%) and small company drivers (14.5%). Overall small company drivers appear to travel at faster speeds on average compared to the other driver types, and large company drivers travel at slower speeds. Possible reasons for this, such as scheduling and loading constraints, will be discussed in later sections of the report.

The average speed for owner drivers was 81.01 kph. However, this varied by type of owner driver. Fleet owners had a mean speed of 85.91 kph, followed by independent subcontractors 82.01kph, independent owner drivers 79.81kph, and prime contractors 77.69 kph. Graph 15 presents the average speed over the trip by type of owner driver.

Most prime contractors had an average speed of between 70 and 80 kph as indicated by the averages, being somewhat lower than the other owner driver types and all other drivers. They also have the highest proportion in the under 70 kph category (20%). Independent subcontractors and fleet owners have the most drivers in the over 100 kph category, 5.2% and 7.1% respectively. Only 4% of prime contractors and 3.5%

of independent owner drivers were in this category. In general it was found that fleet owners travel at the highest average speeds and prime contractors at the lowest average speeds.

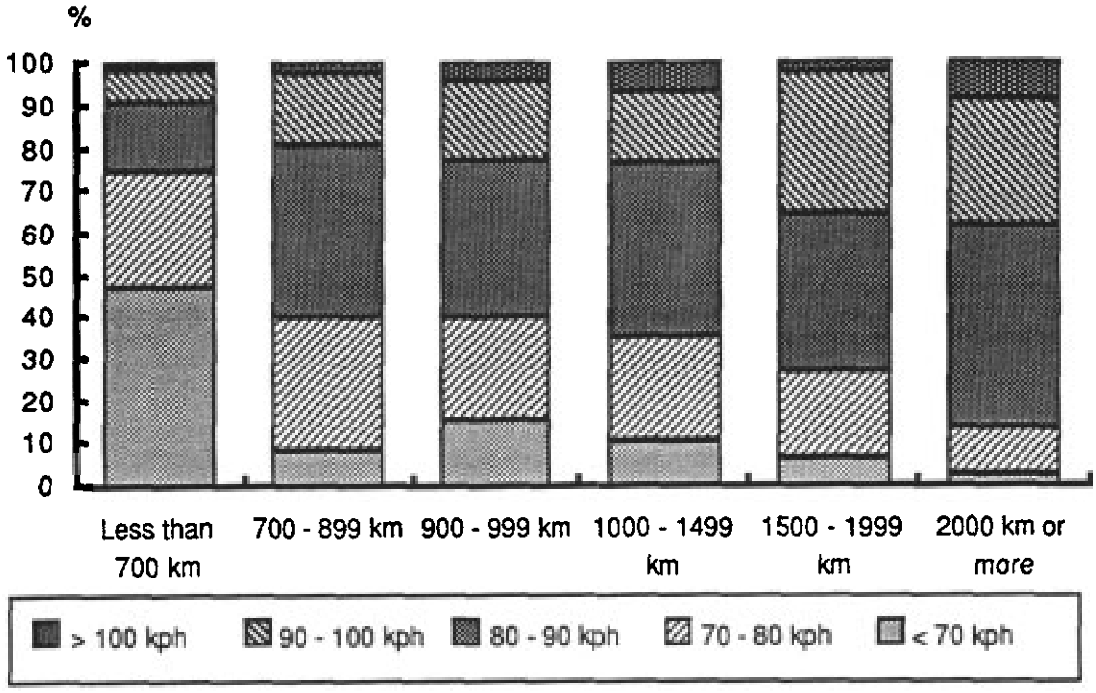
Graph 15 *Average speed of trip by type of owner driver*



There also appears to be a relationship between the average speed for the trip and the length of the trip (see Graph 16). We found that the average speed on shorter trips was lower than the average speed on the longer trips. This could be influenced by the fact that the shorter journeys may have a higher proportion of time spent in urban areas with slower speed limits. Longer trips, such as Perth to Sydney, or North Queensland to Sydney also provide the opportunity for faster travel on roads which carry a lower volume of general traffic. For example, 47.3% of drivers travelling less than 700 km had an average speed of less than 70 kph, and only 2.3% of drivers travelling over 2,000 km had an average speed of under 70 kph. Nine percent of drivers completing trips over 2,000 km long had an average speed of 100 kph or more, compared to only 1.4% of drivers travelling under 700 km.

We found little evidence of a relationship between average speed of the trip and the total time of the trip in hours. Total trip time includes driving and non-driving time.

Graph 16 Relationship between average speed and trip length



The average speed on the main routes of the sample of trips is shown in Table 11.

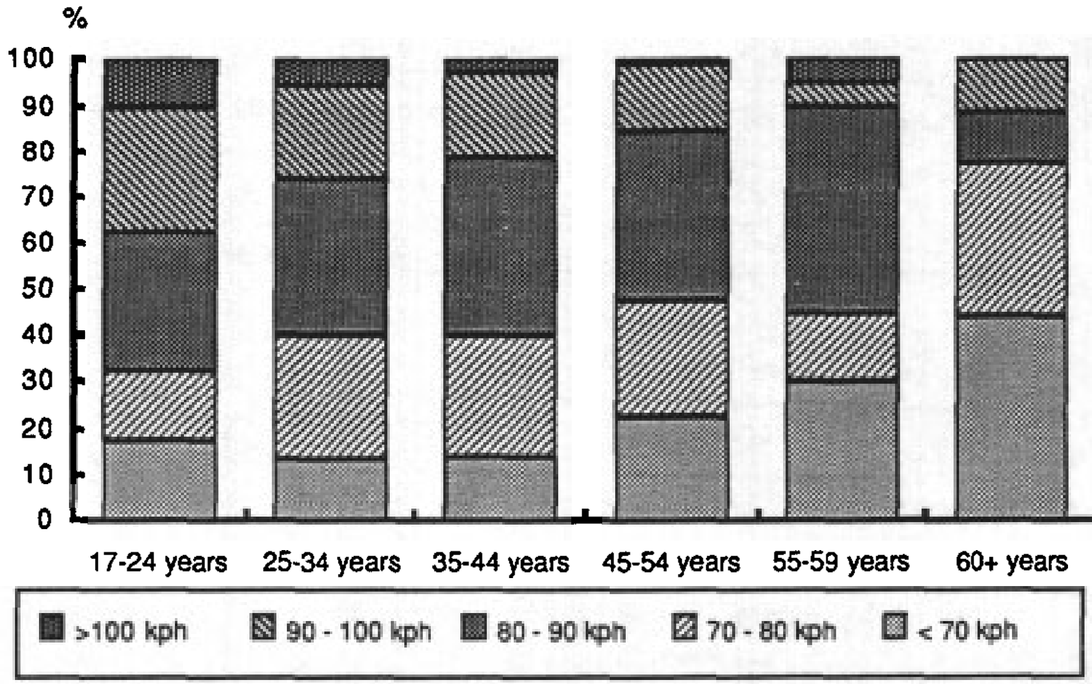
Table 11 Average trip speed by route

Origin	-> Destination	km/h	No. of trips
Sydney	-> Melbourne	89.16	(25)
Adelaide	-> Sydney	89.02	(27)
Rest of VIC	-> Sydney	86.08	(56)
Perth	-> Sydney	85.46	(19)
Melbourne	-> Sydney	83.48	(136)
Melbourne	-> Brisbane	83.31	(22)
Other Routes		82.68	(260)
Rest of QLD	-> Sydney	79.34	(50)
Brisbane	-> Sydney	78.45	(57)
Sydney	-> Brisbane	77.26	(41)
Rest of NSW	-> Sydney	76.80	(56)
Sydney	-> Rest of NSW	70.29	(17)
Woll./N'castle	-> Sydney	65.30	(20)
Sydney	-> Woll./N'castle	57.01	(19)
TOTAL		81.06	(805)

It is apparent that the average speeds for trips between Sydney and Victoria are higher than those for trips between Sydney and Queensland, regardless of the direction of the trip. It is interesting to note that one of the longest routes (Adelaide to Sydney) has the highest average speed while the 3 shortest routes (all to or from Sydney) have the 3 slowest average trip speeds. Intrastate trips were slower than interstate trips. The 4 slowest trips were trips within NSW, with trips between Sydney and Wollongong/ Newcastle having the lowest average trip speed.

A relationship is suggested between the average speed of the trip and the age of the driver. This relationship is shown in Graph 17.

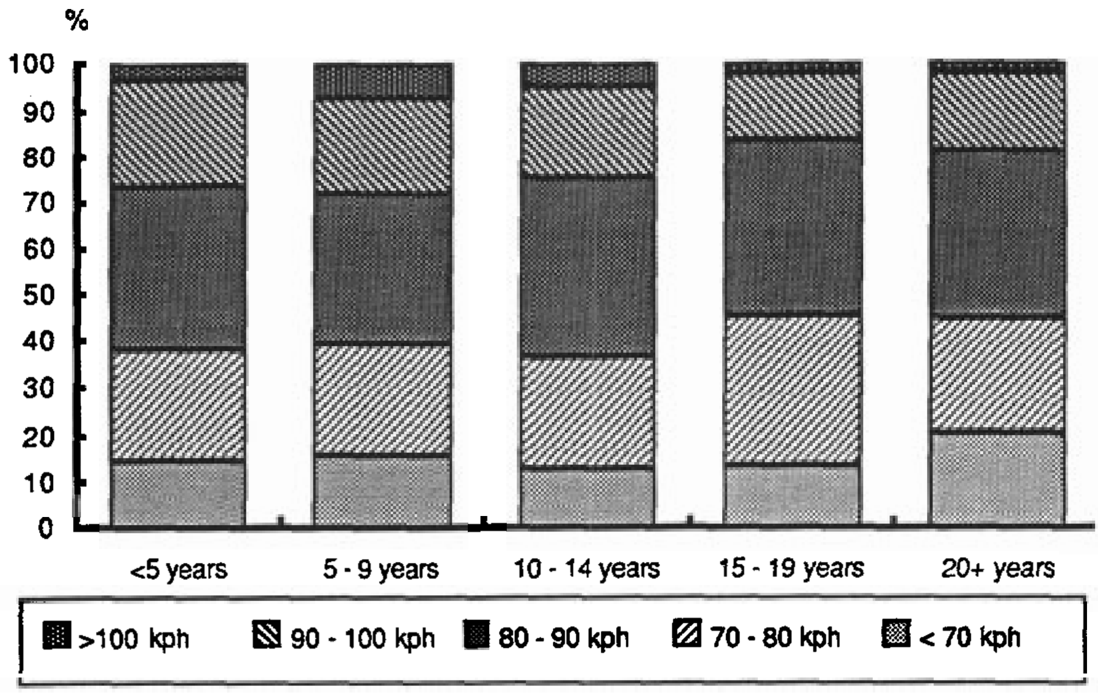
Graph 17 Relationship between average speed and age of driver



Of drivers in the 17 to 24 years category, 26.8% had average speeds in the 80 to 90 kph range and another 27.5% in the range 90 to 100 kph, and the highest proportion (of all ages) in over 100 kph (10.0%). The majority of drivers between the ages of 25 and 59 years travelled between 80 and 90 kph. Forty-four percent of drivers who were 60 years and over had an average speed of less than 70 kph and another 33.3% in the range 70 to 80 kph, with no drivers in the over 100 kph band.

The age of the driver is also an indication of the years of experience driving large trucks. Graph 18 shows the relationship between the number of years experience of the driver and the average speed of the trip.

Graph 18 Relationship between average speed and truck driving experience



The highest proportion of drivers travelling over 100 kph are those with 5 to 9 years experience (7.3%), and the highest proportion in the under 70 kph category are those drivers with over 20 years experience as a truck driver (20.3%).

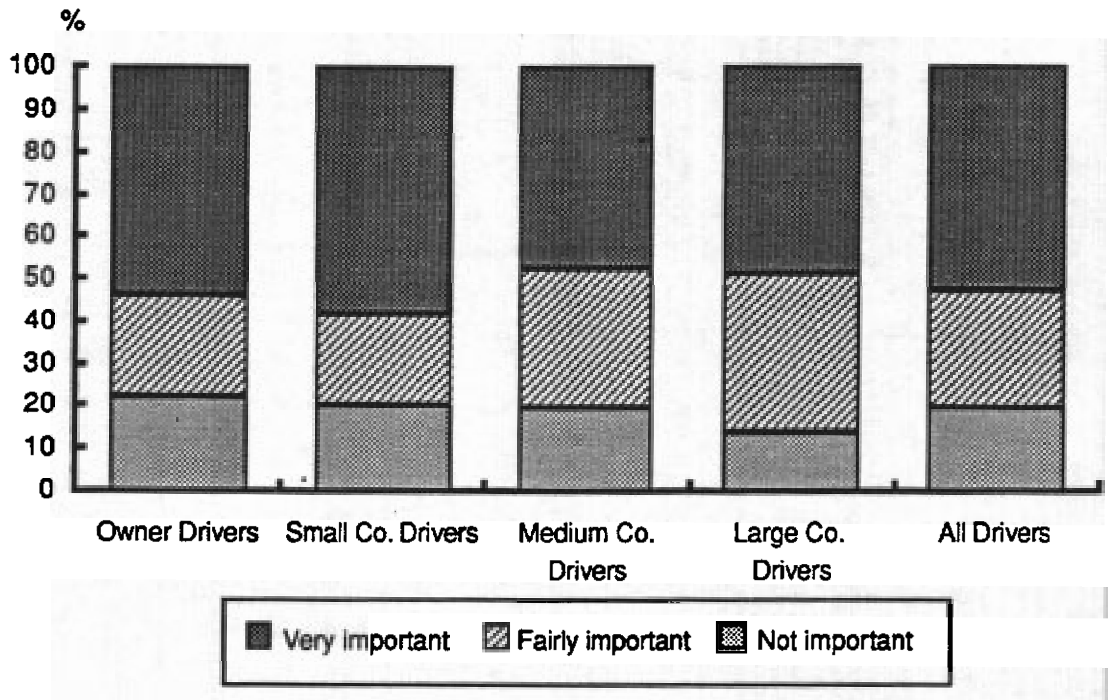
Graphs 17 and 18 indicate that younger drivers with little experience are, on average, travelling the fastest, and the older drivers with the most experience are travelling at slower speeds. Unfortunately there is a tendency for younger drivers to be involved in a greater percentage of crashes. For example, in the United States truck drivers under the age of 21 have a crash rate 5 times the average, falling to twice the average at 21 years (Seiff 1990).

5.1.2 Speed as a contributor to crashes

Speed has been found to be a major factor in articulated vehicle crashes. A study of heavy vehicle crashes in NSW between 1982 and 1988 found that 28% of crashes were associated with excess speed by a heavy vehicle (Sweatman et al 1990). The lack of reports actually citing a statistic for the proportion of crashes caused by speed is due to the fact that it is difficult for crash investigators to reliably discover the contribution of speed to crashes.

An awareness of the importance of speed as a contributor to heavy vehicle crashes was evident in the responses of the drivers interviewed in this survey. Graph 19 shows the percentage of drivers in each category who believe that speeding by heavy vehicle drivers is an important contributor to crashes. Responses from drivers of "important", "very important" or "extremely important" have been combined into one response, shown as "very important" in Graph 19.

Graph 19 Speeding as a cause of crashes

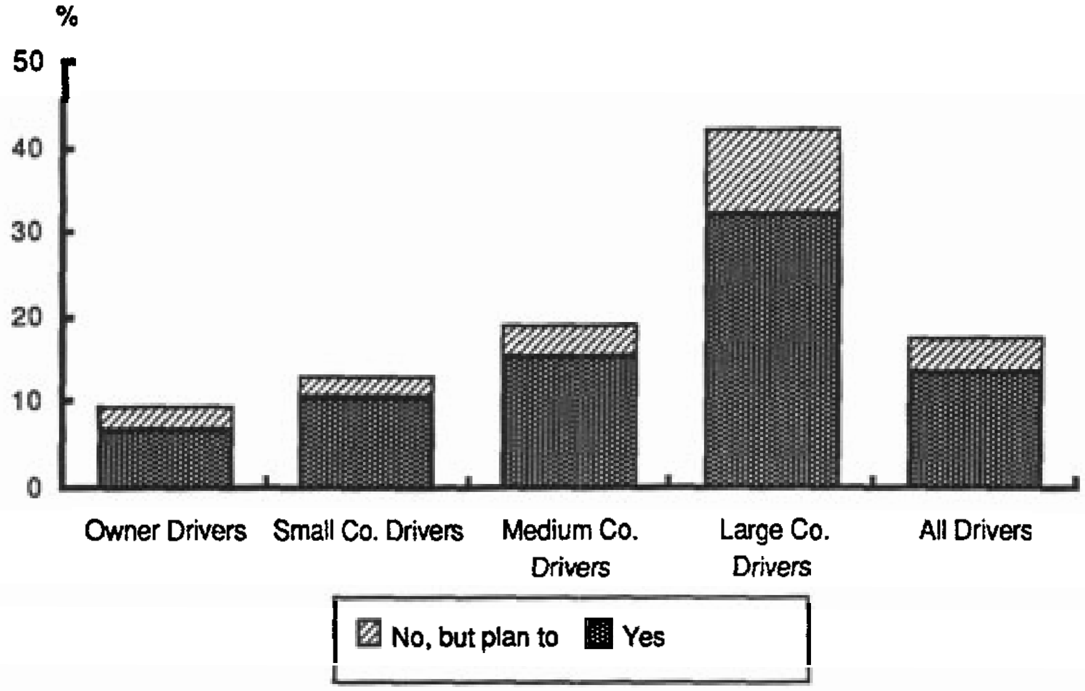


As Graph 19 indicates, over 50% of all drivers believed that speeding was a "very important" cause of crashes. But while the majority of owner drivers and small company drivers said they believed speeding to be "very important", medium and large company drivers did not perceive speeding to be as important as did other types of driver. A third of medium company drivers believed speeding was "fairly important" while large company drivers were split between speeding being "very important" (48%) or "fairly important" (38%).

5.1.3 Speed limiters

Trucks that are speed limited are able to travel at 100 kph on open highways, compared to 90 kph for non-speed limited trucks. Graph 20 shows the proportion of drivers in the survey who were driving trucks which had speed limiters installed and the proportion of drivers who planned to have them installed.

Graph 20 Use of speed limiters



Overall, 13.3% of those interviewed had a speed limited truck, with 4.2% planning to install a speed limiter. A third (32.2%) of large company drivers were driving a truck which was speed limited, compared to only 6.5% of owner drivers. Ten percent of large company drivers indicated that there were plans to install speed limiters in their trucks, compared to only 2.5% of owner drivers.

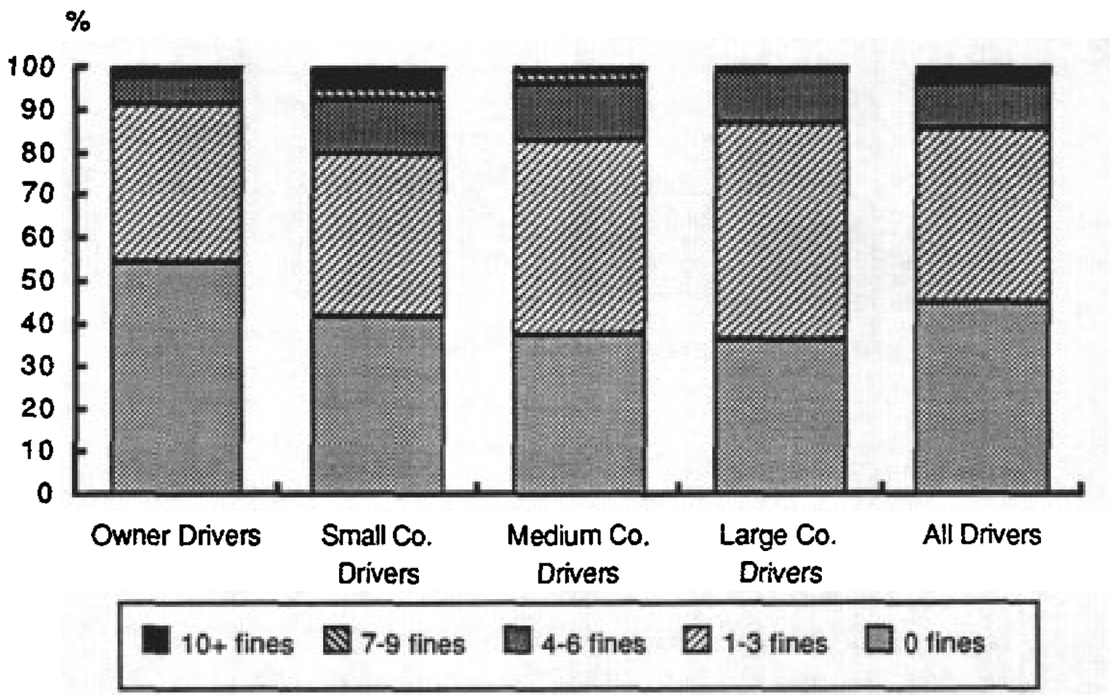
Some operators have speed limiters installed as a fuel saving measure. As from 1 January 1991 all new heavy trucks must be speed limited to 100 kph, and all heavy trucks manufactured after 1 January 1988 must have them installed at re-registration (O'Connor 1991). Speed limiters have the support of the Australian Road Transport Federation.

5.1.4 Speeding fines

Fifty-five percent of drivers interviewed had received at least one speeding fine in the 12 months preceding the survey. Graph 21 shows the number of fines by driver type.

Of those drivers who had been fined, the highest proportion had only 1, 2 or 3 speeding fines in the last 12 months. Large company drivers had 50.8% in the 1 to 3 fine category, followed by 45.2% of medium company drivers, 37.5% of small company drivers, and 36.1% of owner drivers. Small company drivers had the highest proportion of drivers who had received more than 3 fines (20%) and more than 10 fines, the highest category. Five percent of small company drivers had received 10 or more fines, compared to only 1.9% of owner drivers, and 1.6% of medium and large company drivers.

Graph 21 Number of speeding fines incurred by drivers over the last 12 months

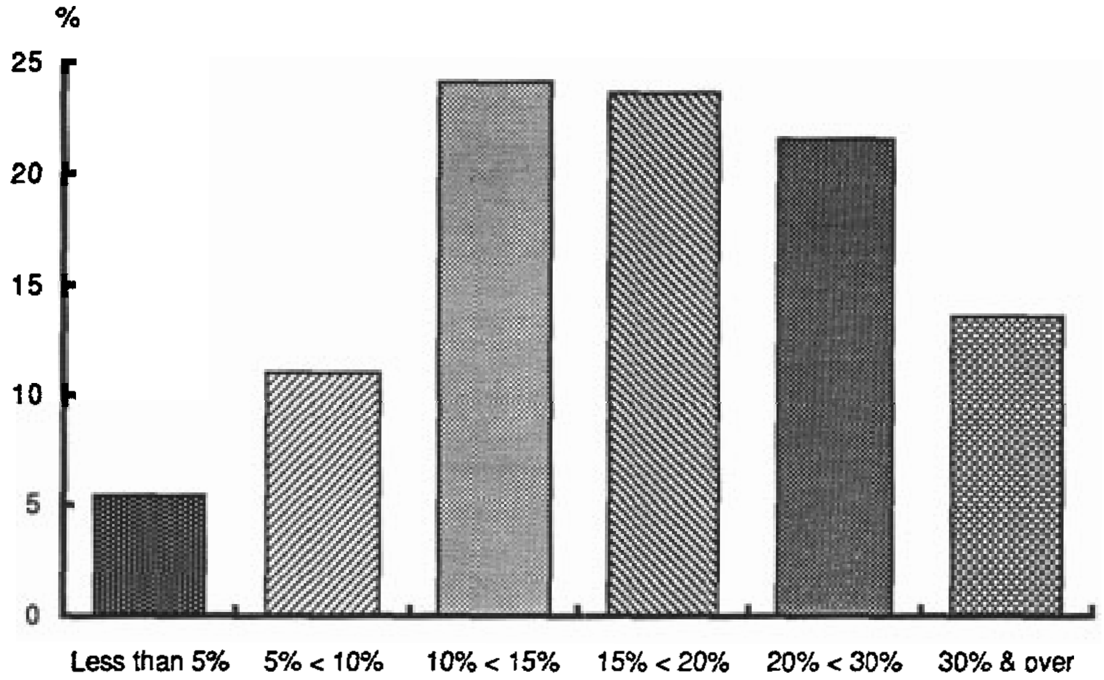


It could be expected that those drivers who have higher driving hours per week are at a greater risk of being caught for speeding and thus fined. The average number of fines for drivers who drive over 100 hours per week was 2.09, compared to 1.81 for those driving less than 100 hours.

Drivers were asked to quote the speed at which they were fined and the legal limit for the speed zone in which they were travelling. The percentage speed over the limit was then calculated, and is shown in Graph 22.

Approximately half of the fines were for speeds of 10 to 20% over the speed limit. But a significant number of fines, about 13%, were for travelling 30% over the speed limit. Three drivers claimed that they were travelling below the speed limit when fined. The highest percentage of owner drivers (25.5%) and large company drivers (27.7%) were fined travelling at 10 to 15% over the legal speed limit. A higher percentage of small company drivers (28.5%) were fined at 15 to 20% over the speed limit, and medium company drivers (27.3%) at between 20 and 30% over the limit. Medium company drivers had the highest proportion in the category of 30% or more over the speed limit (15.4%), followed by owner drivers (12.4%), large company drivers (11.6%), and small company drivers (9.7%)).

Graph 22 **Percentage speed over the legal limit**



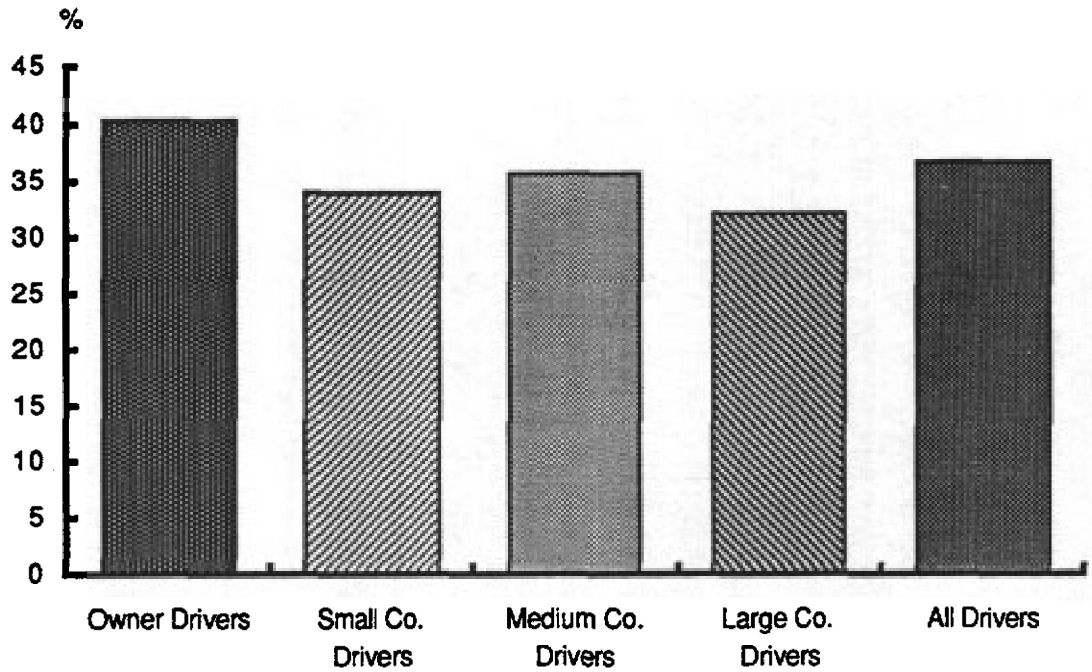
Drivers were particularly critical of the police attitude towards truck drivers. There were many reports of what was considered unfair victimisation of drivers and of "phantom bookings". It was maintained by many drivers that it was common for police to book drivers at fabricated speeds just to make money for the government or to victimise truck drivers. When asked for their opinion of police surveillance on the road, 26% of respondents said that surveillance should be open and 11% said they disliked unmarked cars (27% of drivers fined for speeding were caught by unmarked cars). Sixteen percent of respondents believed that the police are just revenue earners for the government, and victimise truck drivers, especially in NSW (12%).

5.1.5 Schedules

One of the hypotheses to be explored in this study is the impact of scheduling constraints on the speed at which drivers travel on the road. This section discusses the results of the questions on scheduling in relation to the specific trip chosen for analysis and also on drivers' opinions of scheduling requirements in the industry in general.

Drivers were asked whether they had a scheduled time of arrival for the specific trip analysed. The results are presented in Graph 23.

Graph 23 Scheduled time of arrival

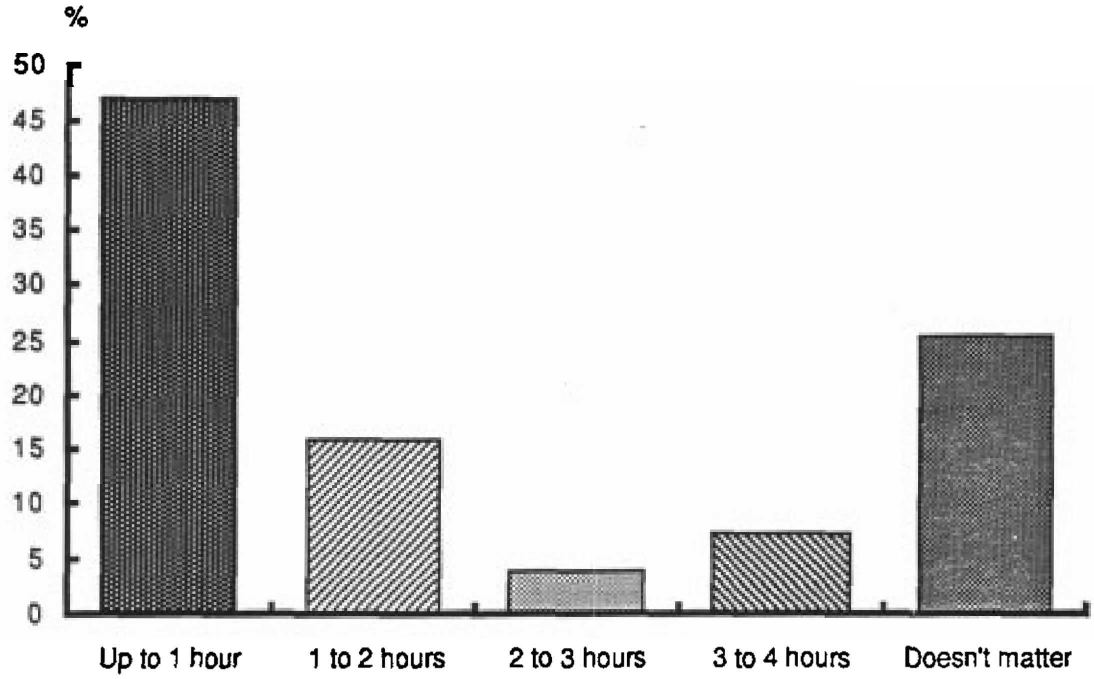


About 35% of all drivers in the survey had a given scheduled time of arrival for their trip. There was however very little variation in the incidence of schedules across the different types of drivers. Owner drivers had the highest proportion with a scheduled time of arrival (40.3%), and large company drivers the lowest (32.0%).

The impact of scheduling constraints is also influenced by the margin allowed for lateness. Graph 24 shows the percentage of drivers who were allowed a range of margins of lateness. We found that there were no differences here by driver type. Of those drivers with a scheduled time of arrival (36.5% of the sample), 47.2% would be considered late for up to one hour after the scheduled arrival time, and 16.1% at 1 to 2 hours after the scheduled arrival time. Thus for these drivers there is not much leeway in the scheduled time for the trip. Just over 25% said that it did not matter how late they were after their scheduled time of arrival.

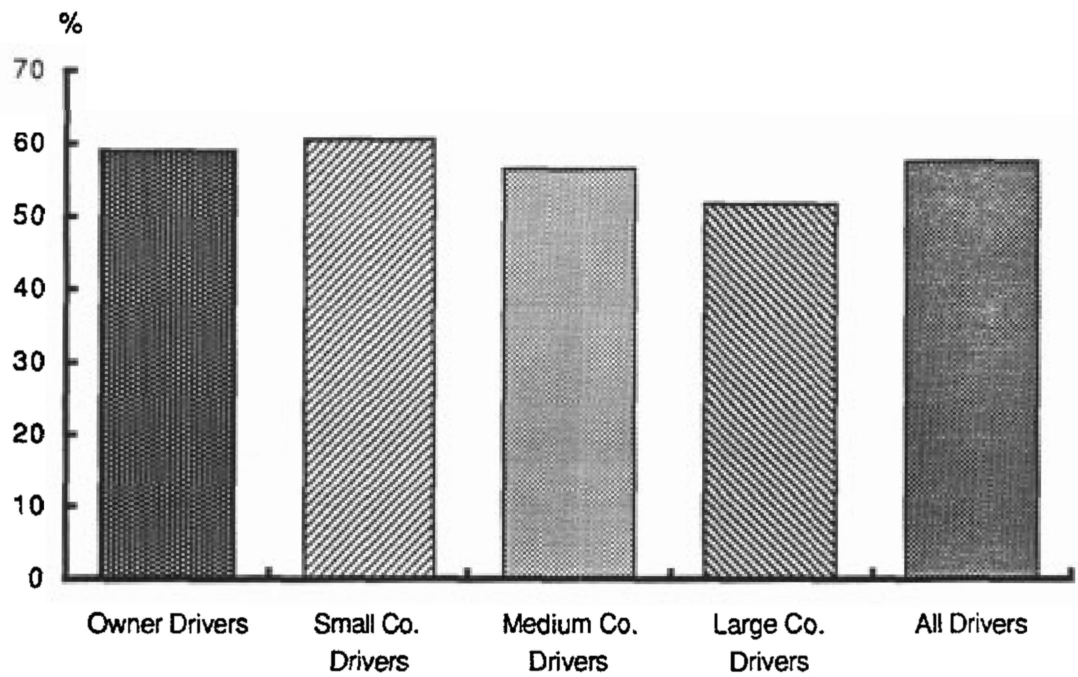
Of those drivers with a scheduled time of arrival, 2.7% were offered an incentive such as a bonus or more work, to meet the schedule. A quarter of drivers with schedules reported that they would be penalised if they did not keep to the set schedule. Penalties ranged from being verbally abused, to being fined or having their pay docked. As many employee drivers are paid by the trip, there is already a built-in economic incentive to complete the trip in minimum time.

Graph 24 Margin of lateness allowed in set schedule



Although only 37% of the drivers surveyed indicated that they had a set schedule for the specific trip, the pilot survey suggested that drivers often set, or at least aimed for, their own scheduled time of arrival. All drivers were asked if it was important for them to arrive at their unloading point before a particular time even if it was not scheduled by an employer or freight forwarder. The responses are shown in Graph 25.

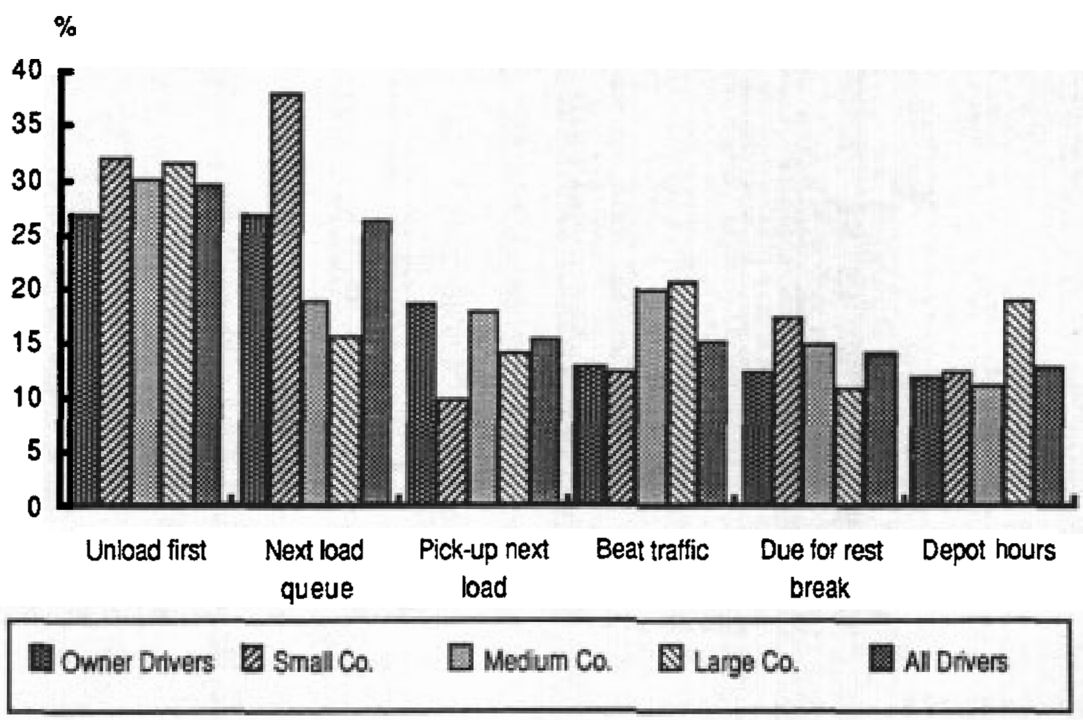
Graph 25 Self-imposed scheduled time of arrival



Approximately 60% of all drivers reported that it was important for them to arrive at a certain time, even if a schedule had not been set by the freight forwarder or the owner of the freight. There was very little difference according to the type of driver with 60.5% of small company drivers, 59.0% of owner drivers, 56.4% of medium company drivers and 52.7% of large company drivers aiming to arrive at a particular time on the sampled trip.

The most important reasons given by each type of driver for imposing their own scheduled time of arrival are shown in Graph 26. For the majority of drivers the main reason revolved around the importance of being in the queue or being unloaded ready to take on the next load. For owner drivers, 26.8% wanted to unload first, 26.8% wanted to get in the queue for their next load, and 18.5% had another load arranged to pick-up. Small company drivers mostly wanted to get in the queue to be allocated the next load (38.0%), 32.2% wanted to be unloaded first and 17.4% were due for a break. Medium company drivers wanted to unload first (30.2%), followed by wanting to beat the traffic (19.8%) while 18.9% had another load to pick-up. Large company drivers predominantly wanted to unload first (31.7%), then beat the traffic (20.6%) and comply with the hours of the depot (20.6%). These constraints are for the most part self-imposed, but are most likely to be a symptom of the underlying economic pressures in the industry.

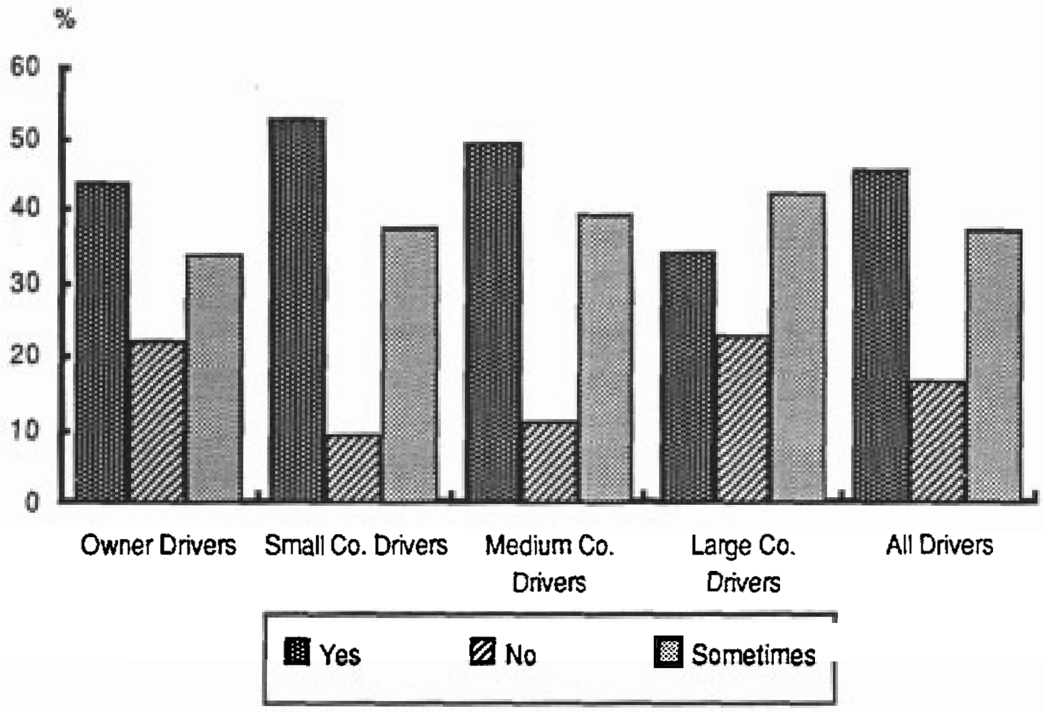
Graph 26 Reasons for self-imposed time of arrival



In general approximately 50% of all drivers were of the opinion that freight companies demand unreasonably tight schedules. This percentage was very similar across all types of drivers, though it was slightly lower for large company drivers and for prime contractors. The opinions of drivers with regard to the setting of schedules by freight forwarders are shown in Graph 27 by type of driver.

As in the pilot survey, drivers commented on the general lack of concern on the part of the freight forwarders and owners of freight about the implications for the safety of the road environment in expecting deliveries to be made within certain times. Over 7% of drivers said that the freight companies might hold them up all day, load them in the afternoon, and still expect the driver to drive overnight to deliver the load. Over 5% said that the freight companies are not interested in the drivers, and 4.8% said that freight forwarders have no idea how long trips take.

Graph 27 Setting of schedules by freight companies



It is not possible from this very basic descriptive analysis to determine the role of scheduling in influencing the speed of the driver on the road. The importance of schedules, particularly self-imposed schedules, is examined in Section 6 in the framework of an econometric model. The propensity to speed is the result of a complex relationship between a number of factors, of which scheduling is just one. The relationship between schedules and the impact on compliance with the driving hour regulations is also discussed later in section 5.2.3.

5.1.6 Type of cargo and speed

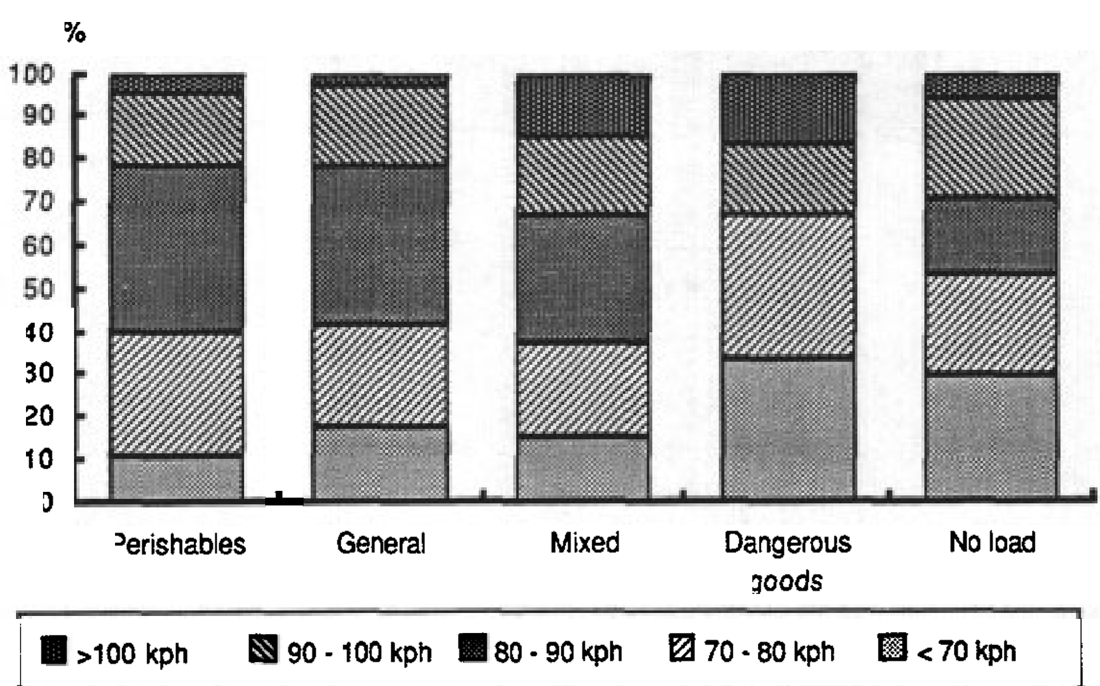
Another hypothesis to be explored is that the speed at which the driver travels on the trip may be influenced by the type of cargo being carried. In particular it is possible that drivers carrying perishable cargo may be under greater pressure to reach their unloading point at a certain time than drivers of general cargo.

The cargo being carried on the driver's trip was classified into four groups: perishables, general, mixed and dangerous goods. Perishables include fruit, vegetables, plants, some groceries, frozen food and livestock. General freight includes steel, metal, machinery, parts, timber and wool, whilst mixed cargo includes combinations of perishable and general cargo.

No particular pattern was found in the type of cargo carried by the type of driver. Most drivers carried general freight, with approximately 20% of drivers carrying perishable goods. Five percent of all respondents carried no load. Most of the drivers travelling without a load were returning from regional centres to larger centres, such as Newcastle to Sydney.

Graph 28 shows the type of cargo carried by the average speed for the trip.

Graph 28 Type of cargo by average trip speed



From this very basic descriptive analysis there appears to be little relationship between the type of cargo and the average speed of the trip.

However there does appear to be some relationship between the type of cargo carried and the incidence of scheduling constraints. As mentioned in the previous section, 36.5% of drivers had a scheduled time of arrival at their final unloading point set by an employer or freight forwarder. This figure varies by the type of load that the driver was transporting. Fifty-three percent of drivers carrying perishables had a scheduled time of arrival, as did 51.9% of drivers with mixed cargo. Only 30.8% of drivers with general cargo had a scheduled arrival time, falling to 17.6% for drivers without a load while none of the drivers carrying dangerous goods had a scheduled time of arrival.

5.2 Fatigue

5.2.1 The role of fatigue in crashes

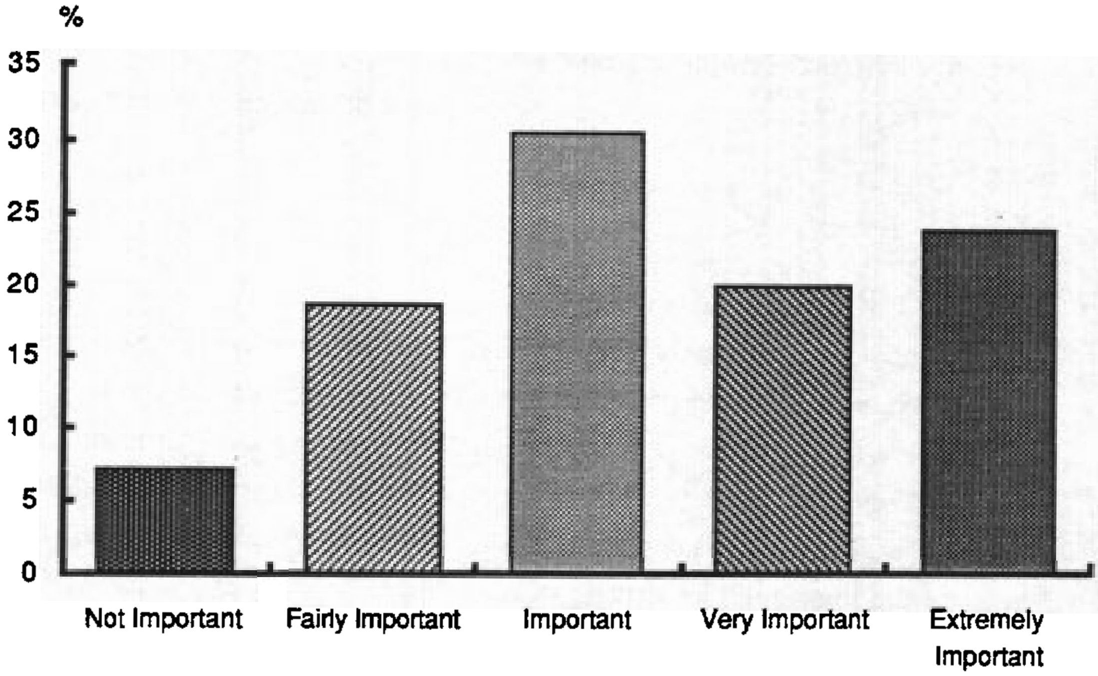
Driver fatigue is a commonly reported cause of crashes involving long distance trucks. Given the annual kilometres travelled by long distance truck drivers it is to be expected that drivers, at least sometimes, experience fatigue on the road. This study focuses on the reasons for fatigue, rather than on the incidence of fatigue, and its implications for road safety. There are many reasons given for why drivers experience fatigue. These include the long hours of driving, the loading/unloading and other work related commitments off the road, the financial pressures of earning a living in a highly competitive industry, alternating day and night shifts, the amount of driving done at night, and the lack of opportunity within the routine to obtain lengthy periods of sleep.

Estimates of the proportion of crashes caused by fatigue vary. For example, a study investigating heavy vehicle crashes in NSW in 1988-89 found that up to 60% involved some element of driver fatigue (Sweatman et al 1990). Other estimates range from attributing 20 to 30% of highway fatalities to fatigue, to 40 to 50% of fatal single vehicle crashes as resulting from fatigue (Staysafe 1989). Staysafe concluded, after examining the evidence on crashes in NSW, that casualties involving heavy vehicles would be reduced by at least 25% if all trips were driven by drivers who were not fatigued (Staysafe 1989). However, these estimates of the role of fatigue in fatal crashes may underestimate the actual effects of symptoms of fatigue such as the impairment of judgement and the ability to anticipate dangerous situations, which may not be identified by investigators in many crashes (McDonald 1984).

Long distance truck drivers believe that fatigue does contribute to crashes. Linklater

(1977) found that 59.6% of drivers interviewed in her study believed driver fatigue contributed to crashes. The findings in this study confirmed this view. Drivers were asked to rate from 1 to 5, where 1 was "not important at all" and 5 was "extremely important", the importance of particular factors contributing to truck crashes. One of the factors was the fatigue of heavy vehicle drivers. The results are presented in Graph 29.

Graph 29 Importance of fatigue of heavy vehicle drivers as a cause of crashes



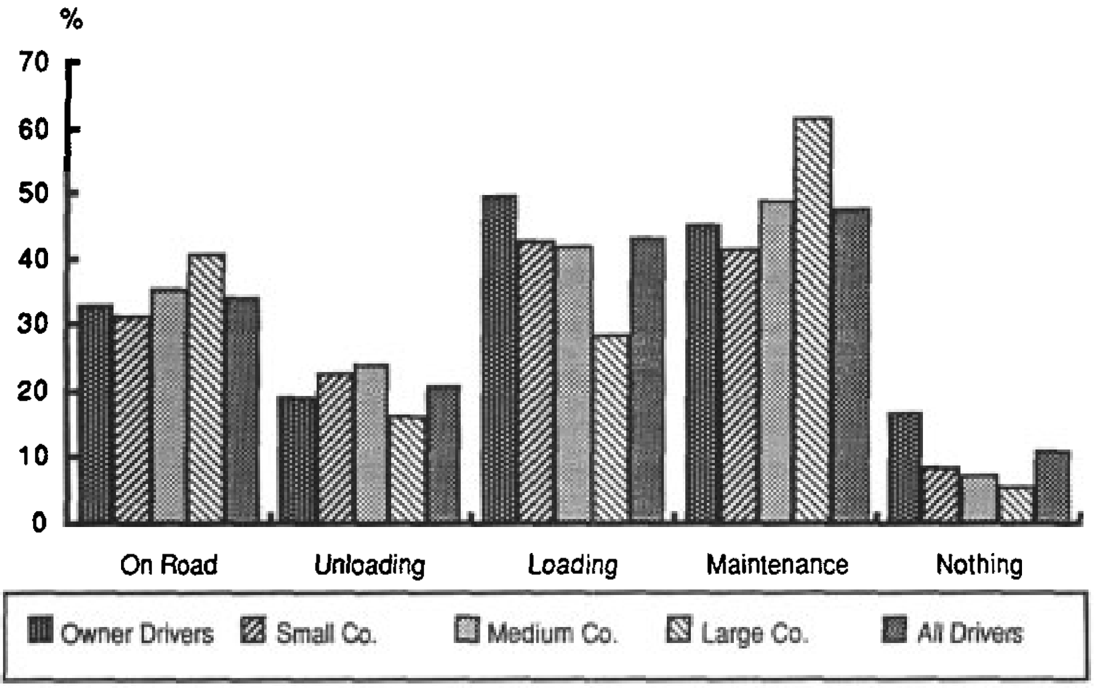
Overall, 74.2% of all drivers believe fatigue is at least an important contributor to truck crashes, with 23.8% of drivers saying that it was "extremely important". No difference was found between the opinions of owner drivers and employee drivers.

A recognition of the role of fatigue in compromising road safety however does not necessarily imply that steps will be taken by the driver to avoid driver fatigue. Nor will drivers necessarily defer their driving until they are rested. Fatigue appears to be accepted by drivers as an inherent characteristic of the industry and of their lifestyle with which they must learn to cope in order to earn a living. This study hopes to reveal some of the underlying causes of this inherent fatigue regime in the industry. The current study by Worksafe Australia is also examining the relationship between work practices in the long distance trucking industry and driver fatigue. It is hoped that as a result of the findings of both these studies that some improvements can be made to the work environment which will reduce the fatigue experienced by long distance truck drivers.

5.2.2 Activities before driving

The activities undertaken by a driver before setting out on a long trip may render the driver fatigued before he begins the driving task. Thus knowledge of the driver's activities in the hours prior to commencing the trip can provide useful information in the search for influences on on-road performance. There is evidence from previous studies that reaction time is increased where physical (as distinct from mental) work was undertaken in the hours prior to driving. In relation to the specific trip selected by each driver, drivers were asked about their activities in the 8 hours prior to departure on that trip. This information highlighted the extremely demanding and stressful workload of the driver when off the road. Graph 30 shows the percentage of drivers engaged in work related activities in the 8 hours prior to departure.

Graph 30 Percent of drivers engaged in work related activities prior to departure



The main off-road activity undertaken by most drivers is loading and unloading the truck. Forty-three percent of drivers spent time loading their truck or waiting for the truck to be loaded. Of these drivers, 13.3% did it on their own, spending between 1 and 2 hours loading. Sixty percent of drivers supervised and assisted the loading with a forklift driver, taking them on average 3 to 4 hours. Therefore these drivers had already spent a significant time doing physically tiring work before they left on their trip.

The proportion of drivers who spent time loading or waiting while the truck was loaded varied substantially by type of driver. Fifty percent of owner drivers spent time loading the truck compared to less than 30% of large company drivers. Owner drivers and small company drivers spent an average of 3 hours loading the truck while large company drivers spent 2 hours 15 minutes. Large company drivers generally have the support of depot staff to load and unload their vehicle for them whereas owner drivers are often completely responsible for loading and unloading their vehicle.

One fifth of drivers spent some time, on average 2 hours 10 minutes, unloading the truck from their previous trip. Owner drivers and small company drivers spent the most time and large company drivers the least time.

Over a third of drivers (34.4%) had spent some time in the last 8 hours before departure completing the previous trip or driving to the loading site. This varied by type of driver, with 41% of large company drivers having spent some time on the road. The average time on the road was approximately 2 hours 20 minutes. However over 10% of these drivers had spent over 5 hours in the previous 8 hours on the road.

The proportion of drivers spending time on maintenance also varied by driver type. Seventeen percent of owner drivers spent time maintaining their truck compared to less than 6% of large company drivers. Small company drivers spent the most time on maintenance (an average of 4 hours) while medium company drivers spent the least time, on average 2 hours 45 minutes.

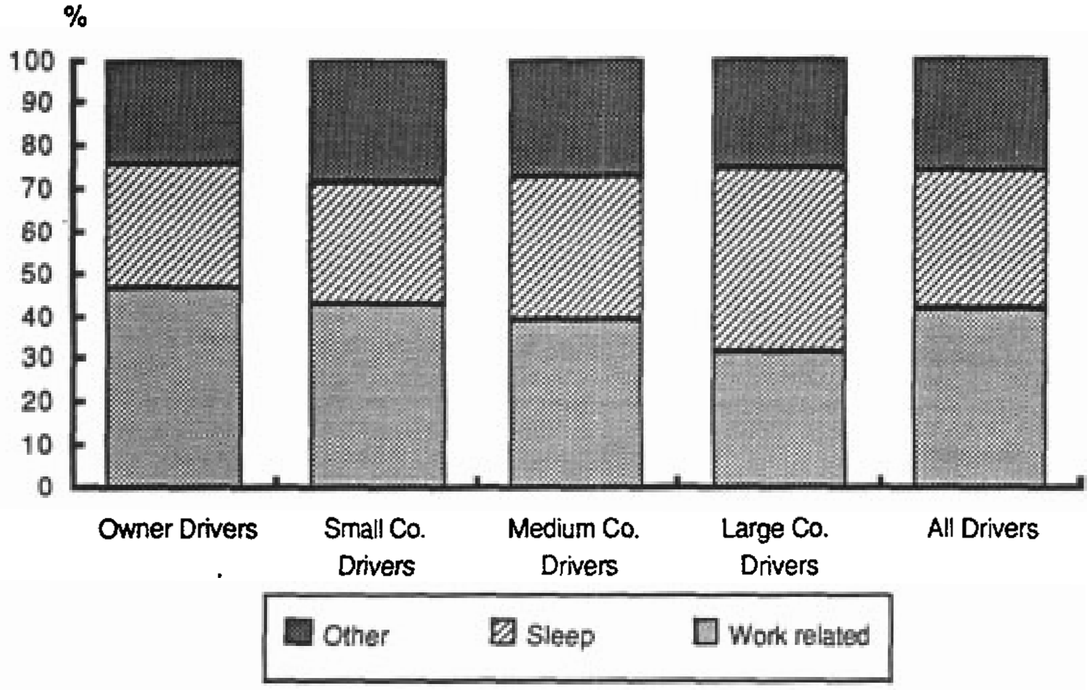
Owner drivers were more likely to have spent time doing nothing, waiting for a load (11%) than other driver types. However the 6% of large company drivers who did nothing spent an average of 4 hours 30 minutes waiting around.

Approximately half of all drivers (52.4%) did not spend any time sleeping in the 8 hours prior to departure. Over 60% of large company drivers spent some time sleeping while in contrast only 41.5% of small company drivers spent time sleeping. Drivers who slept spent an average of 5 hours 22 minutes sleeping, ranging from 5 hours 10 minutes for owner drivers to over 5 hours 35 minutes for large company drivers.

Graph 31 summarises activities in the 8 hours before departure by driver type. Overall approximately 42%, or an average of 3 hours 20 minutes, of the last 8 hours before departure on the sampled trip was spent on work related activities, including driving, loading or maintenance. On average a further 2 hours 35 minutes (32% of time in the last 8 hours) was spent sleeping. The remainder of the 8 hours before departure (26%

of time or 2 hours) was spent on other, non-work activities including entertainment, leisure and personal business.

Graph 31 Average proportion of time spent on activities in 8 hours prior to departure



However the figures for the whole sample hide strong differences between driver types, particularly between large company drivers and all other drivers. Large company drivers spent less than a third of their time before departure on work related activities (31%) compared to owner drivers who spent nearly half the 8 hours (47%) working. In contrast to other driver types, large company drivers spent more time sleeping than on work related activities. These figures highlight the more demanding work routine of the owner driver compared with that of the large company driver who has the support of other staff in the company to organise loads, maintain the vehicle and supervise loading and unloading.

5.2.3 Total hours worked

In section 4.1 the number of hours a week worked by drivers was discussed. It was found that the average working week (including driving and non-driving activities) of a long distance truck driver was 105 hours. This figure is influenced by the fact that many drivers perceive that they work 24 hours a day, 7 days a week. Obviously, such long hours are very fatiguing for drivers and could influence their on-road performance. Studies by Linklater (1977, 1978) found that the average working week of drivers was 71.6 hours. This is somewhat lower than the findings of this study.

Linklater also found evidence that those drivers who exceeded 55 hours of work a week had an increased risk of crash involvement. As our sample of drivers who had been involved in a crash was quite small, we were not able to statistically examine the relationship between the number of hours worked and the involvement of the driver in a crash.

Regulations covering the number of continuous driving hours allowed and the required rest breaks in a given period are attempts to control the level of fatigue of drivers. The number of rest hours and driving hours permitted in Australia vary between the states. The current "driving" hours regulations in Australia are given in Table 12.

Table 12 Driving regulations for truck drivers in Australia (hours)

Regulation	NSW	Vic	Qld	WA	SA	NT
Maximum driving time without rest	5.0	5.0	5.5	5.5	5.0	5.0
Minimum rest period	0.5	0.5	0.5	0.5	0.5	0.5
Maximum driving time in 24 hours	12.0*	12.0	11.0	11.0	12.0	12.0
Minimum continuous rest in 24 hours	5.0	5.0	10.0	10.0	5.0	10.0

Note: * Drivers can drive for another 2 hours if they will reach their destination.
Source: Inter-State Commission, 1988.

Although the regulations are couched in terms of driving hours and are generally thought of in this context, the term driving hours does not refer exclusively to time behind the wheel. In fact, driving hours means working hours. Staysafe 15 (1989) states that "time spent within the vehicle, working on or in connection with the vehicle, or working on any load carried by the vehicle is included as time spent driving". However, the regulations should specifically state that it is for "work" time on and off the road. As discussed in an earlier section, work carried out off the road is substantial.

The problem of the definition of driving hours has been acknowledged by the Special Task Group on Driving Hours (1991). In its report the Task Group felt it necessary to note that "all references to driving hours are references to total hours of work ... which includes loading and unloading, vehicle maintenance and so on." The Task Group adopted this approach due to the misleading common usage of the term "driving hours".

The current maximum "driving" hours in Australia are more lenient than those in Europe and the United States which are shown in Table 13.

Table 13 Maximum driving hours in the United States and Europe

Regulation	US	EEC
Maximum daily driving period	10	9 (10 twice a week)
Maximum driving without break		4.5 (excl. waiting)
Working day	15	
Working week	60	
Minimum daily rest	8	11 (av. over 2 weeks)
Minimum weekly rest		45 (av. over 3 weeks)

Source: Staysafe 15, 1989.

The degree of compliance with the driving regulations is particularly important, as it has strong safety implications. From the data in our survey, we were able to examine one aspect of the regulations. That is, the regulation (in NSW, Victoria and South Australia) of a maximum driving time without a break of 5 hours. Compliance was examined in 2 ways: firstly, using the common interpretation of driving hours as actual wheel hours; and secondly, using the legal definition of total work hours.

Only trips that started and finished in NSW, Victoria and SA (approximately 60% of the trips in the sample) were examined. Almost 80% (79.5%) of drivers did not break the driving regulations on any of the legs of the specific trip we sampled. Of those with a scheduled time of arrival the figure fell slightly to 75.2% of drivers with no "illegal" legs in their trip, compared to 81.3% of drivers without a scheduled time of arrival. For those drivers who set themselves a time of arrival, 77.7% had no legs longer than 5 hours, compared to 82% of drivers without a self-imposed time of arrival. This suggests that drivers with a set scheduled time of arrival or a self-imposed time of arrival were more likely to break the law by driving for more than 5 hours without a break.

It is very difficult from our data to examine compliance with the legal definition of "driving" hours taking into account all work activities. Although time spent on activities in the 8 hours prior to departure is known, the order in which activities were undertaken is not known. A driver who spent 6 hours sleeping then 2 hours loading his truck before driving for 5 hours would be breaking the regulations as total work hours would then be over 5 hours without a break. However the leg would be legal if the driver loaded his truck then slept before driving 5 hours. Eighteen percent of drivers in the sample spent at least 7.5 hours in the 8 hours before departure on work activities. It is likely that most of these drivers in fact broke the driving regulation of a break after 5 hours driving (including work activities) and thus were more likely to be susceptible to fatigue.

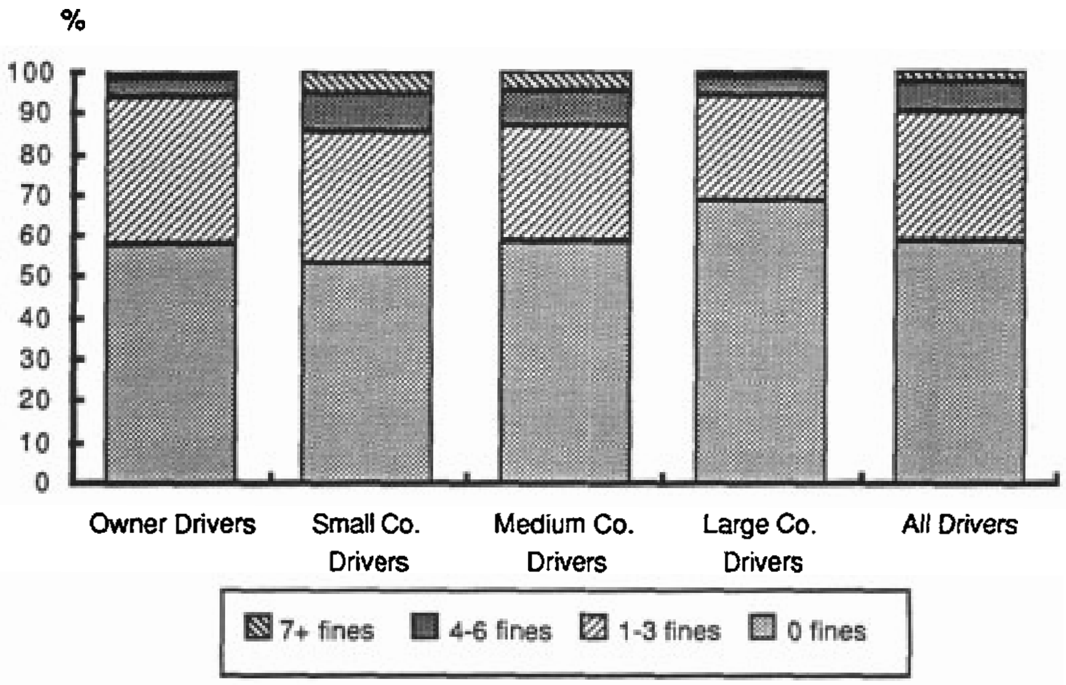
Several studies have found that the risk of crash involvement rises sharply as the number of hours worked before the driver has a break increases. McDonald (1984) found crash involvement to be 2.5 to 3 times higher after 14 hours of work than after less than 10 hours work. Jones and Stein (1987) in a study in the U.S., cited in Staysafe 15 (1989), found that the relative risk of crash involvement for drivers who had driven for more than 8 hours was almost twice that for drivers who had driven less than 8 hours. From this survey it seems that small company drivers are the most likely to break the driving time regulations. Combined with the fact that they also travel at the highest average speeds in the sample, this suggests that they are responsible for exposing themselves, and other road users, to a high level of risk.

One method of alleviating driver fatigue is to use two drivers on a trip. This is referred to as "two-up driving". In the survey only 2.6% of the sampled trips had two drivers. These trips were typically over 1,000 km long, and often over 2,000 km. There are arguments for and against two-up driving. The argument in support of two-up driving is that drivers are not tempted to violate their maximum driving times in order to deliver the freight at the designated time. However, countering this argument is the consideration as to whether the relief driver, resting in a cramped cabin in the vehicle, obtains sufficient rest to drive safely. Research in the U.S. has found that two-up driving is more dangerous than using one driver who takes the required rest breaks (NRMA 1990). The sample of two-up driving trips in this survey is too small to draw any statistically significant conclusions about the relative merits of this practice. At present unions are against the practice in most cases and it is banned in Queensland (AUSTROADS 1991).

5.2.4 Log books

Log books are used to maintain a record of driver hours and hence monitor compliance with the driving hours regulations. However, as reported in a number of studies, they are not an effective method of controlling driving hours as they are too easy to fabricate (Staysafe 1989). Graph 32 shows the number of log book fines by driver type found in the survey.

Graph 32 Number of log book fines incurred by drivers in the last 12 months



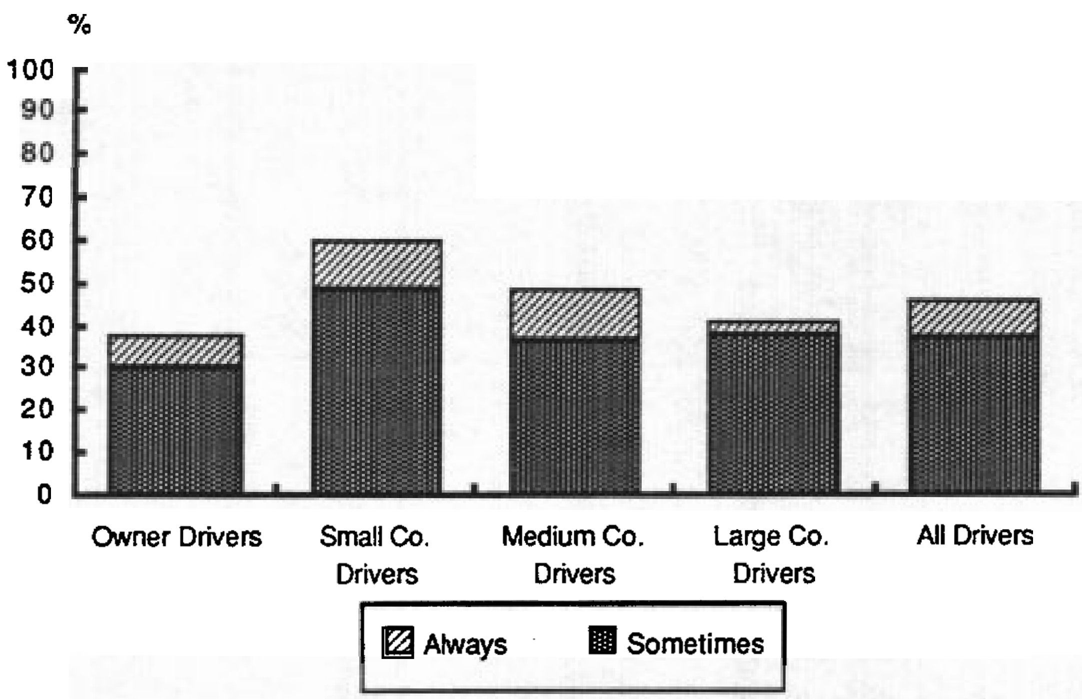
It was found that 41% of drivers had received log book fines in the year preceding the survey. Large company drivers had the lowest number of fines, with 68.9% of drivers not having received a log book fine. Small company drivers had the lowest proportion of drivers without a fine (53.5%). Small and medium company drivers had 5% each in the 7 or more fine category compared to only 1.3% for owner drivers and 16% for large company drivers.

As was the case for speeding fines, those drivers on the road for longer hours a week have a greater chance of their log book being inspected and consequently being fined. The average number of fines for log book infringements for drivers who drive over 100 hours per week was 2.03, compared to 1.25 for those driving less than 100 hours.

5.2.5 Use of stimulants

It is a widely held belief that many long distance truck drivers resort to taking stimulant drugs to maintain alertness on long trips. The findings in this study confirmed this belief. A significant proportion of drivers admitted to taking stimulants to stay awake whilst on long trips. Of the drivers interviewed, 8.8% took stimulants on every trip, with 37.3% taking them on some trips. In total 46.1% of drivers interviewed take stimulants at least on some trips. The use of drugs by driver type is shown in Graph 33. This is slightly higher than the 40.7% found in the Linklater (1978) study of long distance truck drivers.

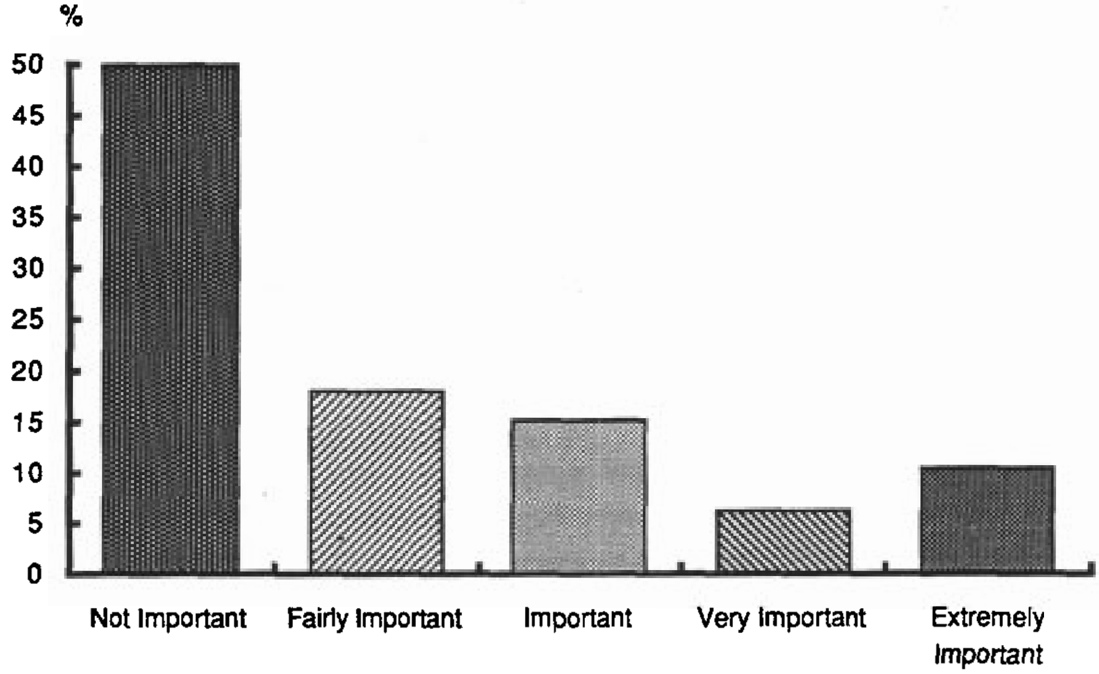
Graph 33 Use of stimulant drugs



These figures suggest that owner drivers take drugs the least, with 7.4% taking them on every trip and 30.3% taking them sometimes. A higher percentage of small company drivers than any other driver type admitted to taking stimulants with 11.5% taking them on every trip and 48.5% taking them sometimes. A similar proportion of medium company drivers took pills on every trip, 11.7%, with 36.7% taking them sometimes. Only 3.3% of large company drivers take pills on every trip, with 37.7% taking them sometimes. Although these figures are slightly lower than those found in the pilot survey, they still indicate a high incidence of dependence on stimulant drugs by long distance truck drivers.

Stimulant drugs do not guarantee driver alertness, and can even cause hallucinations and sudden drowsiness whilst driving. Linklater (1977) found that of the drivers using stimulants, 28.8% reported experiencing hallucinations whilst driving within the preceding year. However, approximately 50% of drivers interviewed in this survey did not seem to be concerned about the dangers of using stimulant drugs and did not consider them to be an important contributor to truck crashes (Graph 34).

Graph 34 Importance of stimulant drug use as a cause of crashes

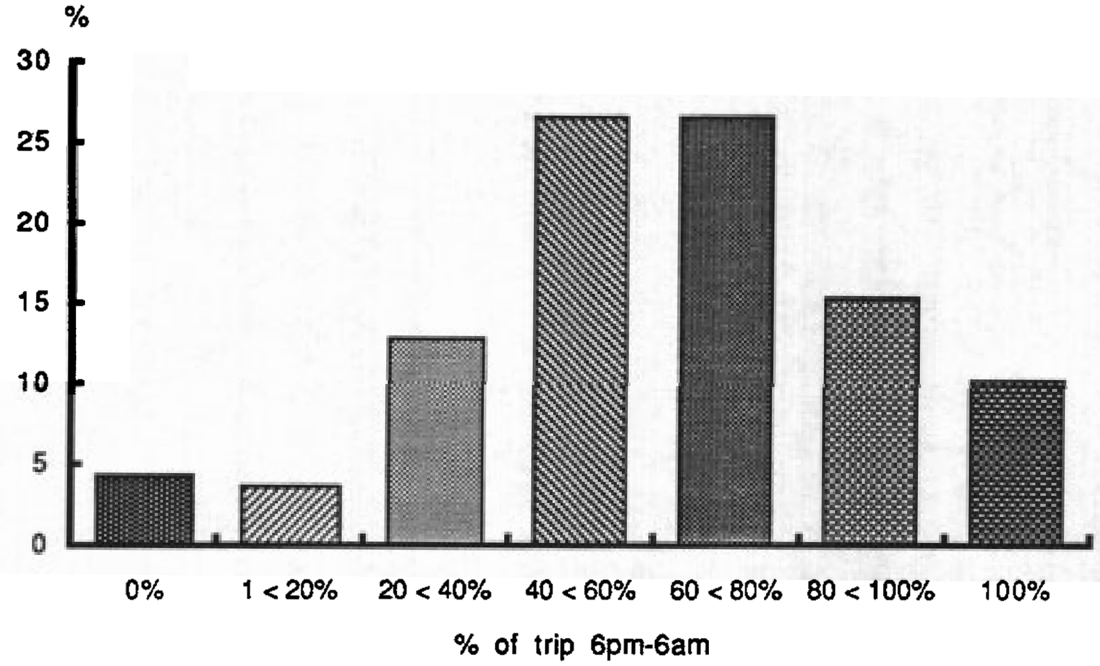


Of all drivers, 49.9% said that stimulant drug use by truck drivers was not an important factor in truck crashes. This did not vary by driver type. Possibly this is because many drivers perceive that their driving skills are enhanced by such drugs. The AUSTROADS report (1991) contains claims that the use of amphetamines in clinical doses may actually reduce crash risk, particularly if the driver is fatigued. However, the report also states that amphetamines may impair some driving skills, such as the judgement of speed, and long term use can have serious side effects which could result in an increased risk of crashes (AUSTROADS 1991).

5.2.6 Night time driving

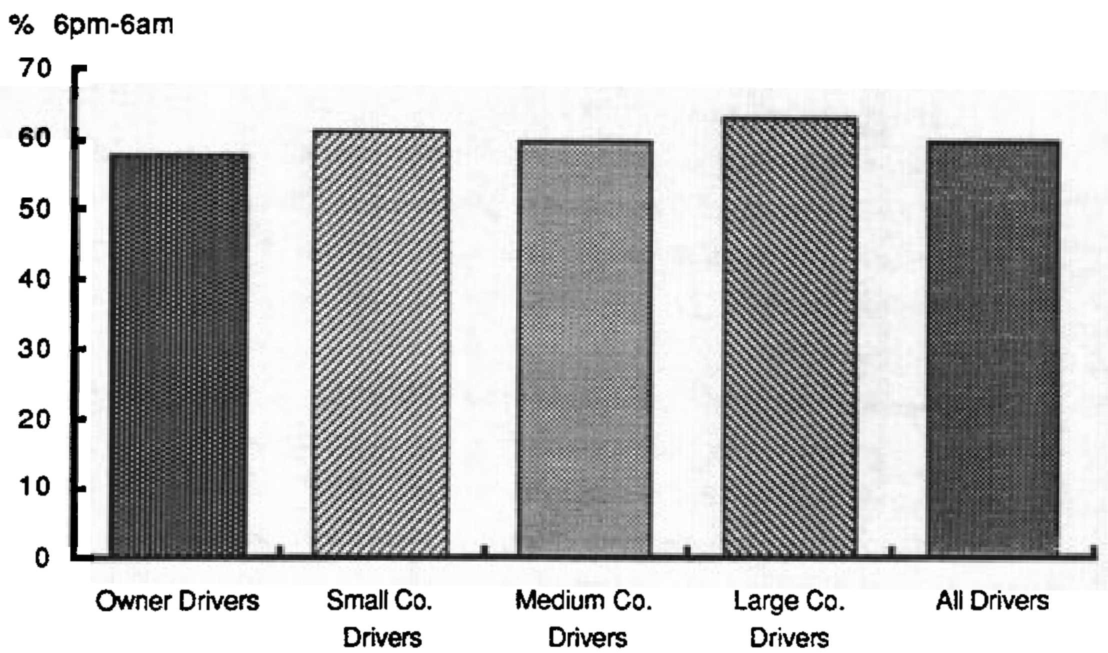
Evidence also suggests that a higher proportion of crashes occur at night and that fatigue is greater during night time driving. Hence we looked at the time of day that the sample trips were driven. We defined "day" as the hours between 6am and 6pm and "night" as between 6pm and 6am. Graph 35 presents the percentage of the designated trips driven during the day and night. For over half the trips sampled, at least 40% and up to 80% of the trip was driven at night. A further quarter of trips (25.6%) were driven almost totally at night (80% to 100% at night).

Graph 35 Percentage of trips driven during the day and night



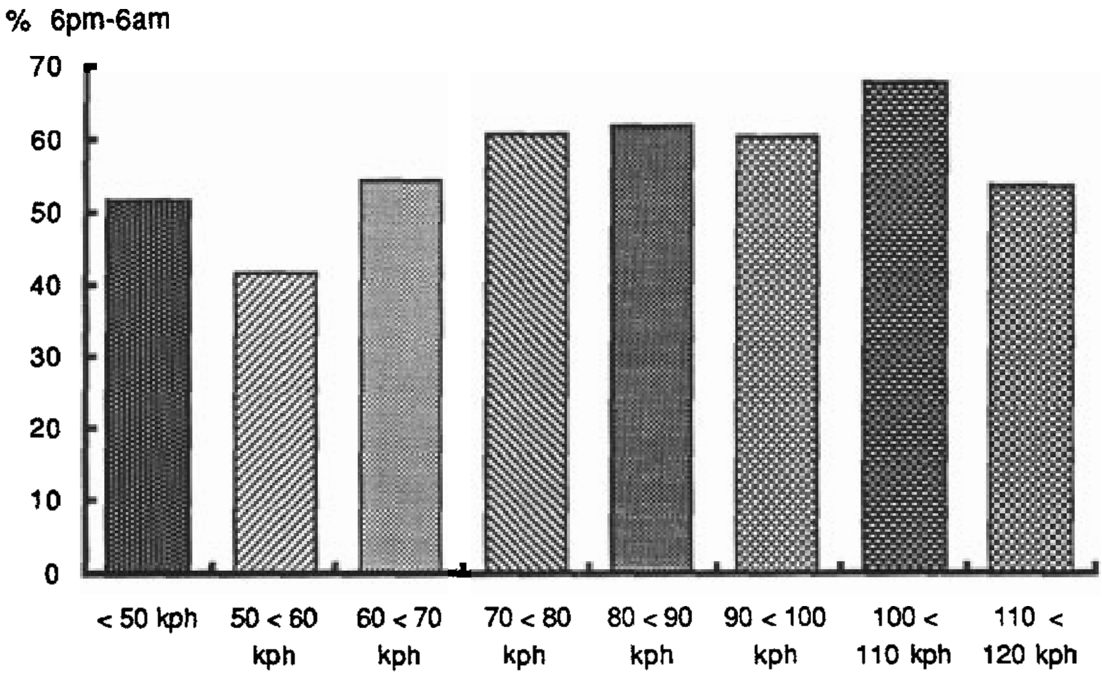
Graph 36 shows the proportion of the sampled trip driven between 6pm and 6am by driver type. On average 60% of a trip was driven at "night". The proportion of the trip driven at night varied only marginally by type of driver with employee drivers, especially those working for large companies, tending to drive more at night.

Graph 36 Percentage of trip driven at night by type of driver



The average trip speed also varied by the proportion of the trip driven at night (Graph 37). Trips in which the average speed was less than 70 kph had a lower proportion of night time driving (less than 55%) while trips with an average speed of 70 to 100 kph had a slightly higher than average proportion of night time driving. The 24 trips with an average speed of 100 to 110 kph involved 68% of the trip being driven at night. However the 8 trips with the highest average speed spent less than the average proportion of the trip time driving at night, only 54% compared to the average of 60%.

Graph 37 Proportion of a trip driven at night by average trip speed

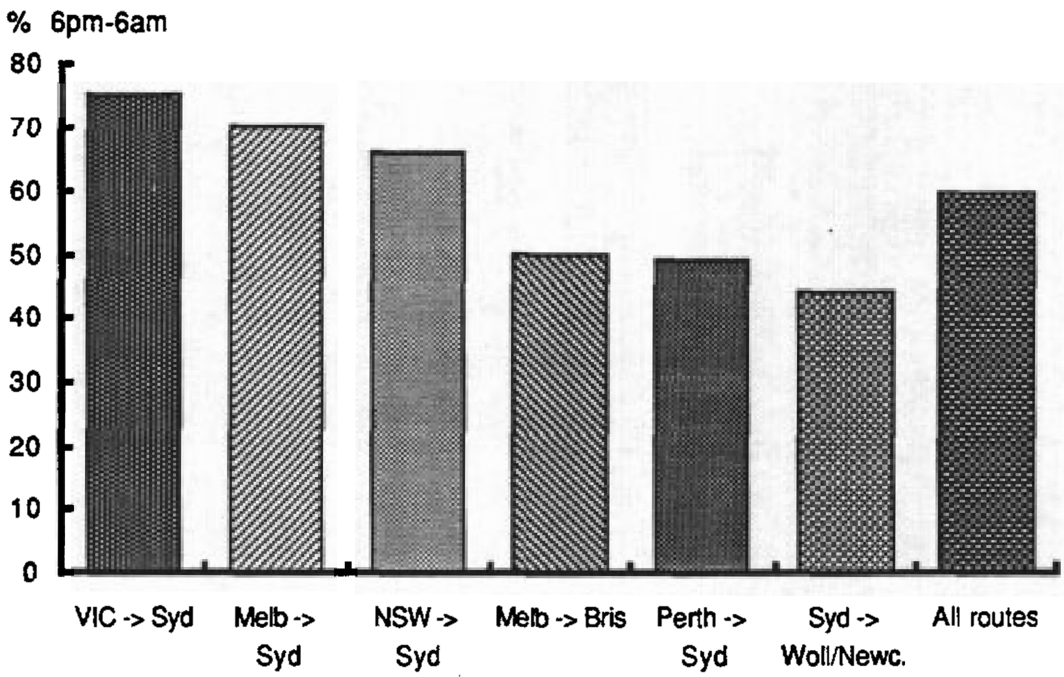


Trips that were driven wholly within the day had a substantially lower average speed (64.5 kph) than those trips driven either partly or wholly at night. Interestingly, however, trips driven wholly at night had a lower than average speed of 78.4 kph. Contrary to expectations, the average speed of the trip did not increase as the proportion of the trip driven at night increased.

Drivers with 4 or more speeding fines in the last year drove a higher proportion of the designated trip at night than average. Those drivers with no speeding fines had the lowest proportion of their trip in the night category (56%). This possibly reflects the fact that they are forced to travel at slower speeds during the day because of the greater volume of traffic on the roads. Drivers with 4 to 6 speeding fines drove 71.8% of their sampled trip at night. This could reflect greater police surveillance at night.

The proportion of a trip driven at night varies by route, as shown in Graph 38. Graph 38 shows that for trips from Victoria to Sydney the average proportion of the trip driven at night was 75.4%. Trips from Melbourne to Sydney also had a higher than average rate of night time driving. Routes with a relatively low proportion of night time driving were Sydney to Wollongong/Newcastle (44%), Perth to Sydney (49%) and Melbourne to Brisbane (50%). It appears that the shortest and longest trips had lower than average proportions of night time driving, whilst middle distance trips had the highest proportion of night time driving. Therefore on medium distance trips, the driver actually chose to drive at night, whilst short trip drivers chose to drive during the day. For long trips, the proportion of day and night driving average out.

Graph 38 Proportion of trip driven at night by route

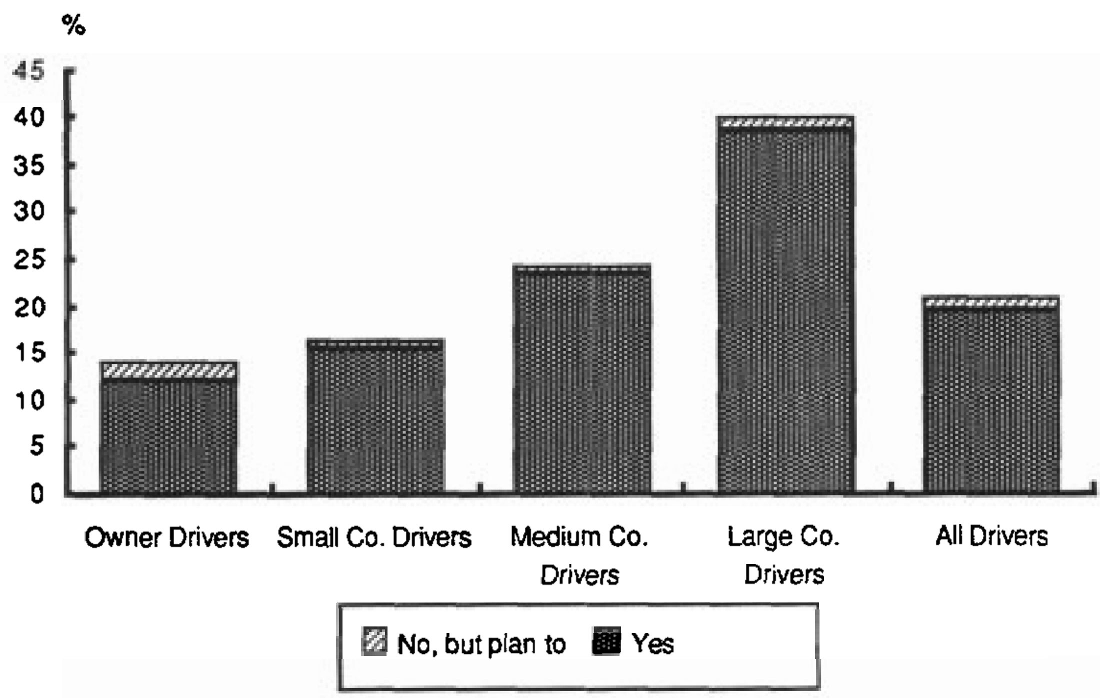


These statistics have highlighted the predominance of night time driving in the road freight industry. Previous research has shown that night driving has important implications for safety. McDonald (1984) found evidence that crash involvement is twice as high at night as during the day. The work by Dr Lisper of Uppsala University in Sweden, has found evidence that there is a differential in reaction time between day and night driving. Research in Europe and the U.S. (Abkowitz 1989) also reports that the hours of the lowest levels of alertness for drivers are between 2am and 7am. If there is evidence to suggest that reaction times are slower in darkness than in daylight, then non-uniform or differential maximum driving periods throughout a 24 hour period should be considered in order to encourage more daylight travel. However there could be a problem with this proposal if road safety is reduced because of the presence of trucks on the road during the day in combination with a higher volume of car traffic. The current demands for "just in time" freight deliveries and express deliveries have established a routine which requires overnight driving. However, in the interests of road safety and the high personal and social costs of road crashes, further assessment should be made of the overall costs and benefits of this practice.

5.2.7 Tachographs

Tachographs have also been proposed as a tool to address the problem of driver fatigue. They record driving hours and thus can provide evidence of breaches of driving hours regulations. In theory, the availability of this information should deter the setting of tight schedules by freight forwarders and the owners of freight and deter drivers from working unsafe hours. Graph 39 shows the percentage of drivers in the survey who were driving a truck with a tachograph and those that plan to have one installed.

Graph 39 Percent of drivers with tachographs fitted to truck



Only 19.5% of the drivers interviewed were driving trucks which were equipped with a tachograph, though this varies according to the type of driver. Of the large company drivers 38.5% were driving trucks with tachographs installed, falling to 23.5% for medium company drivers, 15.6% for small company drivers and 12.1% for owner drivers. Few drivers of any type either planned or knew of plans to have a tachograph

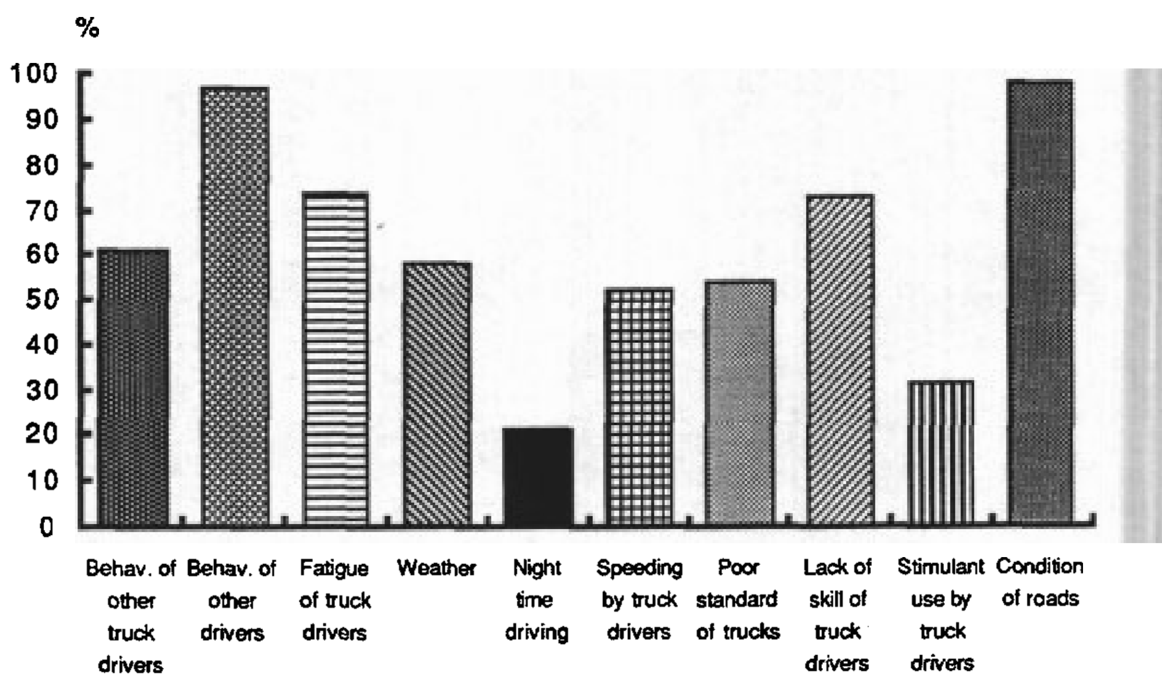
installed in their truck (0.7%). This reflects the widespread opposition in the industry to tachographs.

5.3 Crashes

This section will look at the general causes of crashes involving heavy vehicles and at the actual crashes the truck drivers in our sample had been involved in. The opinion on the need for drivers to complete a driver training course to improve safety will also be considered.

Respondents were asked to rate the importance of ten factors as contributing to crashes on a scale of 1 to 5, where 1 is "not important", 2 is "fairly important", 3 is "important", 4 is "very important" and 5 is "extremely important". The results are shown in Graph 40, with the ratings of "important", "very important" and "extremely important" for each factor being added together to give an overall rating of importance.

Graph 40 Percentage of drivers considering factors to be important in heavy vehicle crashes



The most important factor mentioned by drivers was the condition of the roads (98.3%). This was also mentioned by drivers as one of the major issues facing the industry. The NSW Heavy Vehicle Crash Study found that 73% of the crashes studied could have been avoided through improved roads. The most significant improvement suggested was that the major freight routes should be divided roads. Freeways can reduce the number of crashes by up to 90%, by eliminating head-on collisions and reducing travel times, and thus reducing the number of crashes which occur due to fatigue (Sweatman et al 1990).

Over 97% of drivers believed that the behaviour of other drivers, particularly car drivers, was an important contributor to crashes. Car drivers often behave badly when travelling in proximity to trucks. Examples were cited of cutting in ahead of a braking truck, reducing speed on upgrades, careless overtaking and travelling very slowly for the conditions (Sweatman et al 1990). Staysafe cited anecdotal evidence that many car drivers dislike travelling near trucks and overtake them regardless of their speed (Staysafe 15 1989). The behaviour of other truck drivers was also thought to be an important contributor to crashes by 61.2% of respondents. Drivers are concerned about their poor public image, which they believe has been created by a minority of drivers.

As mentioned earlier in section 5.2.1, drivers believe that fatigue is an important contributor to truck crashes (74.2%). Drivers need to be educated about the causes of fatigue and need to be alleviated of the pressures that force them to exceed the maximum driving hours. Almost three-quarters (73.5%) of drivers believe that the lack of skills of truck drivers is an important influence on crashes. This will be discussed further in section 5.3.2.

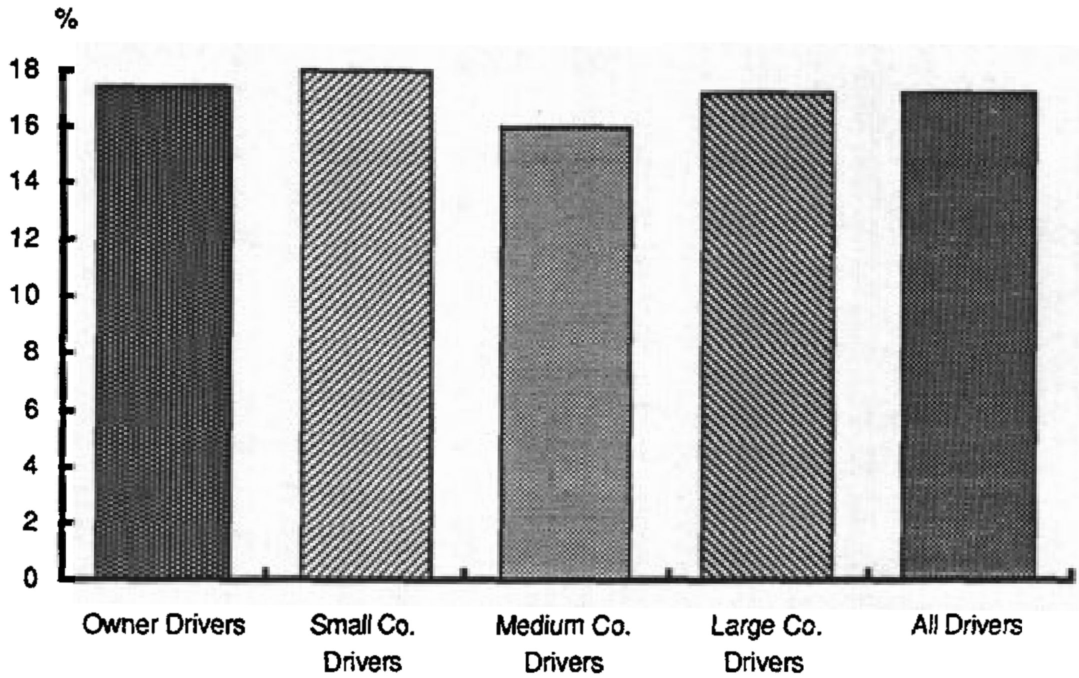
It was also felt by 58.5% of the sample that bad weather conditions played a significant role in crashes. The NRMA studied 149 fatal crashes in NSW in 1987, 1988 and 1989 and found that 30% of them occurred in wet conditions. Fifty-four percent of drivers thought that the poor standard of trucks was an important contributor to crashes. As mentioned in section 4.4.1, a high proportion of drivers in the sample were driving second hand vehicles.

In section 5.1 the contribution of speed to truck crashes was discussed. Over half (52.5%) of the drivers said that speed is an important cause of crashes. Speed also increases the severity of crashes. The use of stimulant drugs by drivers in our sample was found to be quite common, with 37.3% of drivers taking them for some trips, and 8.8% taking them on all trips. However, only 31.9% said that stimulants were an important contributor to crashes. Only 21.5% of drivers believe that driving at night is an important cause of crashes. This figure reflects a surprisingly low level of concern given that research by McDonald (1984) suggests that crash involvement is twice as high at night as during the day. The NRMA found that 39% of fatal crashes occurring between 1987 and 1989 happened at night (NRMA 1990).

5.3.1 Driver involvement in crashes

Drivers were asked if they had been involved in any crashes, to which the police were called, in the 2 years preceding the survey. The results are presented in Graph 41.

Graph 41 Involvement in crashes in last 2 years

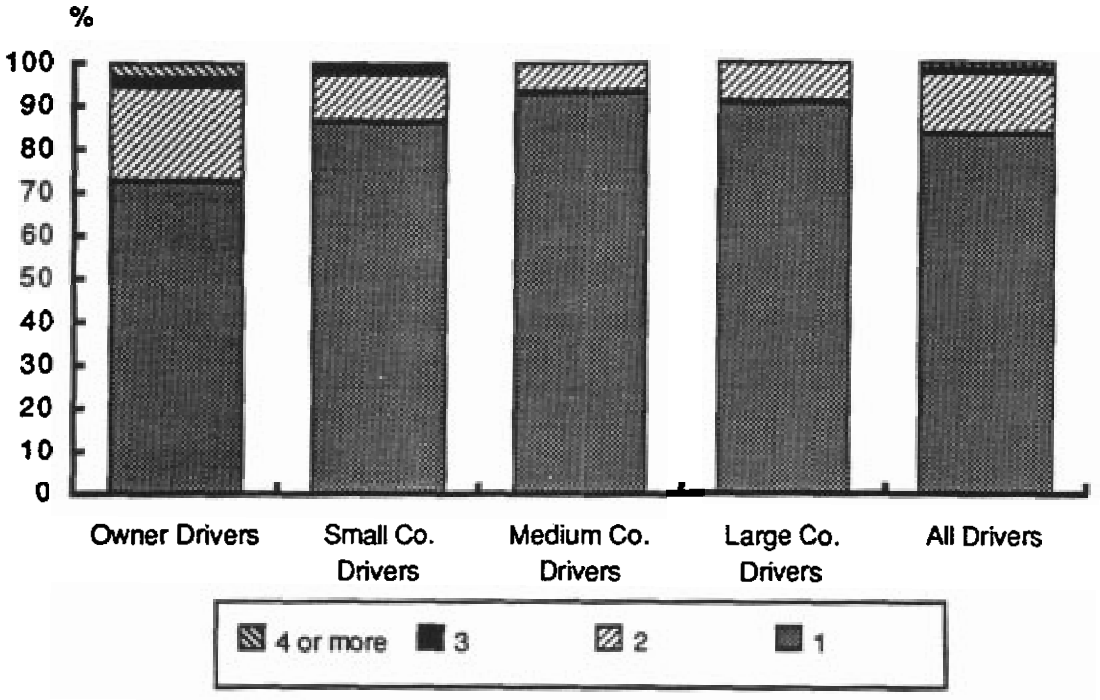


Small company drivers had the highest rate of crash involvement (18.0%), and medium company drivers the lowest (16%), with an overall rate of 17.2%. As speed is a known major contributor to heavy vehicle crashes, this finding is consistent with the result that small company drivers also had the highest average speed over the trip analysed in the survey. For those drivers who had been involved in at least one crash, the total number of crashes in which they were involved in over the 2 years preceding the survey is shown in Graph 42.

Of those drivers who had been involved in a crash in the previous 2 years, owner drivers and small company drivers had the highest number of crashes. For example, 3.8% of owner drivers had 4 crashes or more. All other types of driver had less than 4 crashes. Of owner drivers who had been involved in a crash, 72.2% had 1 crash compared to 93.3% of medium company drivers.

For 73.0% of those involved in a crash in the last 2 years, the most recent crash also involved another vehicle. The majority of these crashes were with a car (80.6%), 8.7% with another heavy vehicle, and 10.7% with another type of vehicle (coach/bus, car towing). Thirteen percent of the most recent crashes reported resulted in a fatality.

Graph 42 Number of crashes (if any) in last 2 years

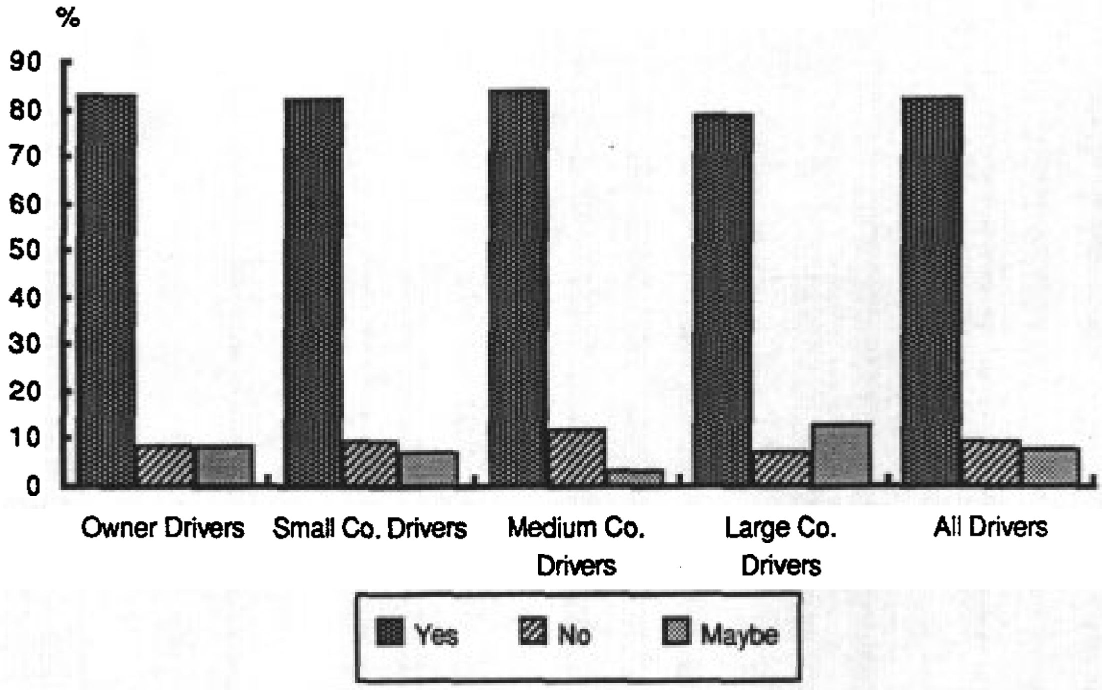


5.3.2 Training

As mentioned in section 5.3, drivers were asked to rate the importance of the lack of heavy vehicle driving skills as a contributor to crashes. As is shown in Graph 40, 73.5% of drivers believed lack of skill to be at least "important". Thirty percent believed it to be "extremely important", and only 10.3% said that it was "not important". The NSW Heavy Vehicle Crash Study found that at least 25% of the crashes it studied could have been avoided, or their severity reduced, if drivers had displayed a higher level of skill (Sweatman et al 1990).

One approach to improving the skills of heavy vehicle drivers is to require the completion of a formal driving course before allowing drivers to obtain their licence. There are currently no such requirements for entry to the industry, or for updating of skills. The opinion of drivers towards completing a formal driver training course before being allowed to drive trucks is shown in Graph 43.

Graph 43 Drivers should complete formal driver training course

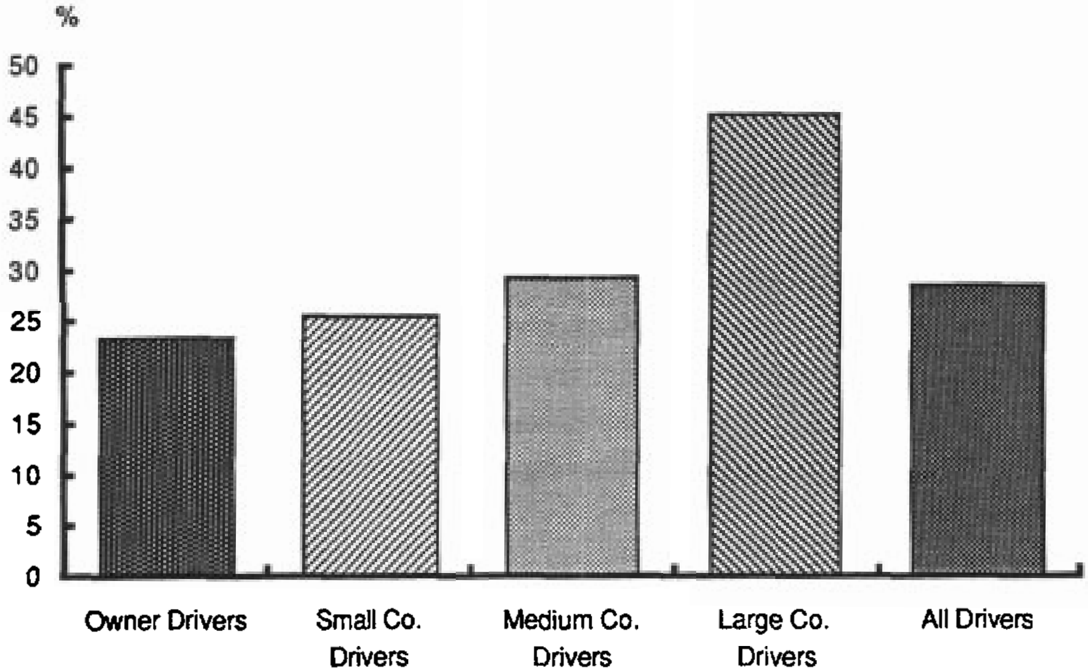


Overall approximately 80% of all drivers strongly supported the requirement of a driver training course. This varied little according to the type of driver. A significant proportion of drivers also commented on the need for a graduated licence system which allowed drivers to gain experience before progressing to larger vehicles. Many drivers also were in favour of truck driving being recognised as a trade with an appropriate apprenticeship scheme. These sentiments and concerns on the part of drivers towards upgrading the general level of skill and reputation of the industry suggest support for any Government policy initiatives in this area.

Although the majority of drivers supported the concept of formal driving training courses for the industry, few drivers, with the exception of the large company drivers, had completed a specialised heavy vehicle training course (Graph 44).

These figures reflect the fact, that apart from the large company drivers, and possibly some of the smaller sized company drivers, a driver training course is not a requirement for entry to the industry. Thus drivers, especially owner drivers, have little incentive to incur the expense and commit the time to complete such a course. Drivers also reported that there is a lack of suitable training courses available, particularly in NSW, though apparently Victoria offers better opportunities for driver training. For those courses that are available, none are accredited on a national basis (AUSTROADS 1991). The WA Owner Drivers Association (WAODA) is presently developing a training scheme for the general trucking industry modelled on a training scheme for the tow truck industry (Australian Transport 1991).

Graph 44 Percent of drivers with specialised training



6. AN ECONOMETRIC ASSESSMENT OF THE UNDERLYING RELATIONSHIPS INFLUENCING ECONOMIC REWARDS AND ON-ROAD PERFORMANCE

6.1 Introduction

Using data collected from our nationwide survey of long distance truck drivers, two econometric model systems were developed to study the underlying influences on economic rewards and exposure to risk. The models build on the descriptive analysis in Sections 4 and 5, from which the key variables used in the models were identified. The data enables us to consider both the annual economic profile of truck drivers and their on-road performance for a specific, recent long-distance trip. The richness of the data enable us to investigate a large number of sources of influence on both economic reward and exposure to risk. Throughout the analysis we assume that there is a positive logarithmic relationship between exposure to risk and speeding, enabling us to use a number of definitions of truck speed as a suitable proxy for exposure to risk.

The many sources of potential influence investigated in this study are summarised in Table 14. These very specific influences, known as *elemental* influences, have been grouped into sixteen broad categories with a common dimension, known as *generic* dimensions. For instance, driver age, number of children, number of crashes and prior occupation are all elemental influences which contribute to the generic dimension of driver background. Similarly, the elemental influences of vehicle weight, age and body type make up the vehicle characteristics generic dimension. Each dimension has been presented as an hypothesis as to its role in influencing each of the variables within the model frameworks displayed in Figure 2.

6.2 The model systems

It is hypothesised that a truck driver is motivated by economic reward and seeks to obtain a return for his efforts through participation either as an owner driver or employee driver. The decision on whether to be an employee or to be self-employed is in part influenced by the opportunities for reward, the flexibility of lifestyle and the extent of a real choice (i.e. the availability of employment in the employee driver sector). Given the highly competitive "cut-throat" nature of the long distance trucking industry, drivers exhibit substantial variations in strategic behaviour in order to survive. The pressures on drivers come from freight forwarders, cargo owners, and the large number of operators competing for loads.

Table 14 Potential sources of influence on economic reward and the propensity to speed

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1. On-Road Profile
   - Total kilometres (TS)
   - Total time (TS)
   - Total number of legs (TS)
   - Incidence of drive time per leg (TS) *
   - Variance of drive time incidence per leg (TS) *
   - Speed profile of trip (TS) *
   - Average speed per leg (TS) *
   - Speed variance across legs (TS) *
   - No. of stops involving particular activities (sleep, rest, eat, etc.) (TS) *

2. Trip Timing
   - Depart during the weekend (TS) *
   - Depart early morning (TS)
   - Depart during the day (TS)
   - Depart during the evening (TS) *
   - Number and percentage of hours driving in the dark (TS) *

3. Pressures on Performance
   - External schedule constraints (TS) *
   - Self-imposed schedules (TS) *
   - Loan repayments *

4. The Road Environment
   - Specific-roads (quality proxy) (TS)
   - Direction of travel on a specific road (TS)
   - Major origin-destination pairs (TS) *
   - Frequency of trips between major origins and destinations *

5. Vehicle Characteristics
   - Body type (rigid, articulated, refrigerated) (TS) *
   - Age (TS)
   - Weight (TS) *

6. Cargo Characteristics
   - Weight (TS)
   - General cargo (TS)
   - Perishable cargo (TS) *
   - Express freight (TS)
   - Specialised cargo (fruit, steel, paper..) (TS)

7. Safety and Security Control
   - Speed limiter installed (TS)
   - Tachograph on board (TS)
   - Incidence of fines (speeding, log book, truck defaults, overloading) *

8. Driver Background
   - Age *
   - Number of dependants (children)
   - Prior occupation (always a truckie, professional, tradesperson) *
   - Undertaken a training course
   - Number of crashes

Table 14 continued ....

9. Industry Experience
   - Years driving
   - Annual kilometres
   - Annual working hours *
   - *Annual driving hours* *
   - Number of trucks possessed *

10. *Lifestyle Attributes*
   - Reliance on pills (always, some trips) *
   - Means of maintaining alertness en route
   - Incidence of activities *in 8 hours prior to departure* (TS) *

11. Preferential Treatment
   - Regularity of contracts (all loads, some loads, no loads) *
   - Access to load (employer organised, bid, one-off, fixed contract, preferential treatment) (TS)
   - Backload provisions *

12. Sub-Industry Status
   - Employee driver (small, medium, large company) *
   - Owner driver fleet owner *
   - Owner driver prime contractor *
   - Owner driver independent sub-contractor *
   - Independent owner driver *

13. Economic Reward Determination
   - Owner driver - $/tonne, cents/km, per load (TS) *
   - Employee driver - *fixed salary, % of truck earnings, per trip* *

14. Structural Constraints
   - Backload available (TS) *
   - Unloading time (TS)
   - Waiting to unload (TS)
   - Time to usually secure loads *

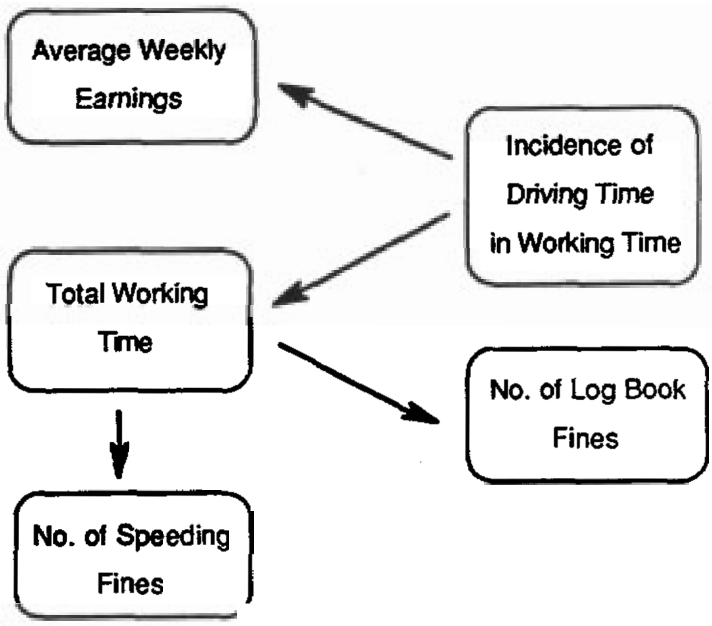
15. Financial Status
   - Annual truck-related income
   - Annual truck-related expenses (owner driver) *
   - *Non-truck related income*
   - Truck financial commitments (nature and size of debt) *

16. Other Dimensions
   - State location of base *

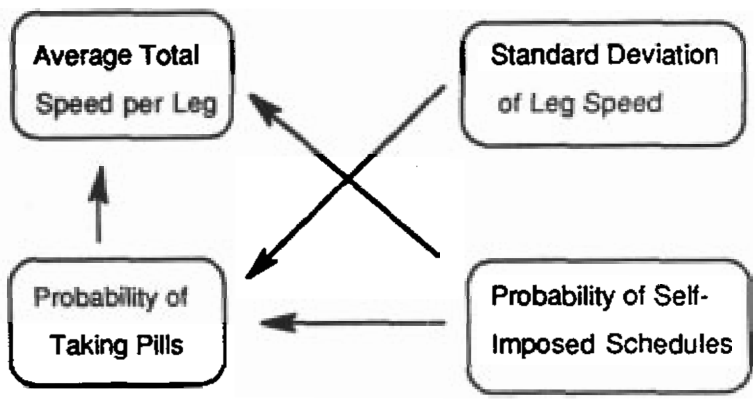
Note: Trip-Specific = TS, * = Included in the model system.

Figure 2 The causal structure of the two model systems

Model system I: Annual economic reward profile



Model system II: Trip-specific exposure to risk



The lifestyle element of trucking, especially for owner drivers and small company employees, has reinforced the acceptability of working practices which in other industries would be regarded as totally unacceptable. Typically, many drivers spend considerable time waiting for an opportunity to secure a load, they rarely sleep at their "permanent residence", spend considerable hours in the cabin of their truck, and live on a "junk-food" diet (AUSTROADS 1991). Reliance on "stay-awake" pills is quite widespread (up to 50% of sampled drivers take pills on some trips or all the time) in order to maintain very long working hours (typically averaging 100 hours per week). Self-imposed schedules which may encourage excess speed are often the outcome of the pressures on truckies, especially owner drivers.

The challenge in this study is to establish the links between good and bad practice, positive and negative incentives and the two key concerns of economic reward and on-road performance in the context of exposure to risk. The evidence can be used to establish some guidelines for changes to be encouraged in the industry which will improve the working environment in a way that both enhances the economic rewards of drivers and their on-road performance.

With these objectives in mind, two causal structures have been investigated:

(i) Model system I - MSI : the annual economic reward profile, and
(ii) Model system II - MSII : the trip-specific exposure to risk.

MSI hypothesises that total working hours are influenced by a number of *exogenous* factors representing the sixteen generic categories of potential influences (Table 14). These factors are used to explain behaviour. Total working hours determine, with other exogenous variables, the proportion of work hours that involve time behind the wheel; and the incidence of wheel hours together with a number of exogenous effects, determine the average weekly earnings of drivers (net of truck-related expenses for owner drivers). MSI develops the descriptive findings presented in Section 4.

MSII hypothesises that on-road performance as measured by average speed per trip leg and/or the standard deviation of the average trip leg speeds is influenced by a number of exogenous variables and two *endogenous* effects - the propensity to take pills and the propensity to adopt self-imposed schedules. Endogenous variables are those that are being explained by the model. Schedules imposed by a company or freight forwarder are exogenously determined and hence are treated as given constraints on behaviour. This influence is hypothesised to operate in one of two possible ways: (i) the propensity to have a self-imposed schedule influences the propensity to use pills which in turn has an effect on the average speed per leg (and the standard deviation across legs) and (ii) the propensity to take pills and to self-impose a schedule jointly influence the on-road speed profile. These models explore further the relationships described in Section 5.

One of the important features of the study is the link between on-road performance and economic reward. The link is achieved via information on the actual rate received for each trip. For owner drivers this represents money earned by the driver, however for an employee driver this represents the earnings of the employer. We were unable to identify the actual earnings for the trip attributable to an employee driver, and so our investigation makes a distinction between the earnings of the owner driver and the earnings of the employer. This is a reasonable context, enabling us to evaluate the role of the freight rate on on-road performance which in the case of an owner driver is also the economic reward. Since each trip's rate or fee is negotiated in a number of dimensions (per load, per tonne, per km) all trip rates were converted to an equivalent rate per kilometre.

The average rates are summarised in section 4.6. Since 7% of owner drivers and 65% of employee drivers did not know the rates, the modelling presents two sets of empirical results: one for the full sample (791 trips excluding fleet operator owner drivers and a few unreliable observations) and one for the trips where the rates are known (410). The decision to present two sets of results was taken to preserve the richness of the full sample in respect of the role of variables other than trip rates. However given the importance of trip rates in providing the trip-specific link between overall economic reward and on-road performance, the smaller sample was analysed. The larger sample was used to identify the set of influences on on-road performance which were included in the reduced-sample model together with separate trip rate variables for owner drivers and employee drivers.

6.3 Econometric considerations

The presence of endogenous right-hand side (RHS) variables which are either measured as continuous variates (i.e. workhours and incidence of driving time) or as discrete binary variates (i.e. the decision to take pills and the choice of a self-imposed schedule) requires a model system utilising advanced econometric procedures. In this section we outline the structure of each of the model systems designed to accommodate endogeneity and the metric specification of the dependent variables.

6.3.1 Model system I - annual economic reward profile

This model contains five endogenous variables (i.e. five equations):

1. Average weekly earnings net of truck expenses (INCPWKN)
2. Incidence of driving time in total work hours (DRVHRS)
3. Total work hours (WORKHRS)

4. Number of speeding fines in the last 12 months (FINES)
5. Number of log book fines in the last 12 months (FINEL)

WORKHRS and DRVHRS appear on the right-hand side of four of the equations. An appropriate econometric procedure for deriving estimates of parameters associated with each right-hand side endogenous and exogenous influence in a system of simultaneous equations is three stage least squares (3SLS) (Greene 1990).

3SLS recognises, and allows for, the non-independence of the error structures of each of the equations. The left-hand side (LHS) variable in a single equation is a function of a set of exogenous variables and a set of unobserved effects, the latter generically represented by the error or disturbance term. When the endogenous variable is introduced into a second equation as a right-hand side variable, it is likely that the error term of the first equation will be correlated with the error term of the second equation since they potentially measure a number of common influences on both endogenous variables. Failure to recognise this possibility and to allow for it can result in biased parameter estimates of the RHS variables. This becomes a source of misleading inference as to the role of RHS variables in explaining variations in the magnitude of the RHS variable.

The technique of 3SLS involves a number of stages of estimation:

(i) Firstly we estimate separate ordinary least squares (OLS) regression equations for each LHS endogenous variable, replacing any RHS endogenous variable by its hypothesised exogenous determinants or instruments specified in the equation where the RHS endogenous variable is on the left hand side.

(ii) Secondly, we estimate by OLS regression each equation again but the LHS variables now are the hypothesised set of exogenous influences and the predicted estimate of the RHS endogenous variable. This step is called two stage least squares (2SLS).

(iii) Thirdly, residuals from these equations are used to estimate the cross equation variances and covariances. The latter estimates are used in a generalised least squares procedure to obtain the 3SLS estimates which are asymptotically more efficient than the 2SLS estimates.

6.3.2 Model system II - trip-specific exposure to risk

This model presents even greater econometric challenges. The endogenous variables are a mixture of continuous and discrete variables. Techniques such as OLS and 3SLS are not appropriate when a dependent variable is discrete (Hensher and Johnson 1981, Greene 1990). Furthermore, when an endogenous RHS variable is discrete, we need to consider the phenomenon of sample selection (or selectivity) which represents the idea of partial inference with respect to each sampled individual's behaviour.

Another way of explaining this is to think of the situation of a driver who is currently taking pills. We observe how this habit affects his driving speed. We do not observe how his driving speed is affected if he did not take pills. Conversely we observe the driving behaviour of a person not on pills, but not his behaviour if he were to take pills. Since the choice of taking pills is an endogenous choice (i.e. the individual chooses himself), the inability to observe each driver's behaviour in the absence/ presence of pills given their current status means that we have potential sample selectivity bias (due to self-selection). Because we have a sub-sample of pill takers and a sub-sample of non-pill takers, we can combine the two samples and use the endogenous dummy variable PILLS together with an auxiliary regressor to test for the effect of any likely selectivity bias due to the absence of such information. If the non-pill takers have characteristics similar to the pill takers which influence their propensity to speed after allowing for sources of influence on the choice between taking or not taking pills, then we would expect to reject the hypothesis of selectivity bias.

Formally, we begin by assuming that the sample of pill taking and non-pill taking drivers are drawn from a **single** population of long distance drivers. For the ith driver, ($i = 1,...,d, ...D$), let y_i be the on-road measure of performance (average speed); z_i the pill taking variable (1 = takes pills, 0 = do not take pills); ω_i the unobserved "lifestyle" and "pressures"; x_{1i} the exogenous vector of k background variables (including the constant); x_{2i} the exogenous vector of m background variables, where x_{1i} is a subset of x_{2i}; and z^* is the unobserved continuous variable determining pill taking. The model system which recognises the relationships between these elements is:

(1) $\quad y_i = \omega_i + \alpha z_i + \varepsilon_{0i}$

(2) $\omega_i = x_{1i}' \beta_1 + \varepsilon_{1i}$

(3) $z_i = x_{2i}' \beta_2 + u_{2i}$

(4) $z_i = 1 \text{ if } z_i^* > 0$
$z_i = 0 \text{ if } z_i^* \leq 0$

Substituting equation (2) into (1) gives equation (5):

(5) $y_i = x_{1i}' \beta_1 + \alpha z_i + u_{1i}$

where $u_{1i} = \varepsilon_{0i} + \varepsilon_{1i}$. It is assumed that u_{2i} is normally distributed and $E(u_{1i} \mid u_{2i})$ is a linear function of u_{2i} such that:

$E (u_{1i}) = E (u_{2i}) = 0,$
$Var (u_{1i}) = \sigma_1^2$
$Var (u_{2i}) = 1,$
$cov (u_{1i}, u_{2i}) = \rho\sigma_1$
$cov (u_{1i}, u_{1j}) = cov (u_{1i}, u_{2j}) = cov (u_{1i}, u_{2j}) = 0 \text{ if } i \neq j$

u_{2i} is constrained to have unit variance without any loss of generality. Let us now define $\theta = - x_{2i}' \beta_2$. Barnow et al (1981) have shown that:

(6) $E (u_{2i} \mid \theta, z_i) = z_i f (\theta_i) / (1 - F (\theta_i)) - (1 - z_i) f (\theta_i) / F (\theta_i)$
$= h_i (\theta_i, z_i) \text{ or } h_i$

where *f*(.) and *F*(.) define the standard normal density and the cumulative distribution functions. It follows that:

(7) $E (u_{1i} \mid \theta_i, z_i) = \rho\sigma_1 h_i$

The application of OLS to equation (7) will produce unbiased estimates of α and β_1 only if $\rho\sigma_1 h_1 = 0$. This condition can be satisfied if one or more of the following requirements are met:

a. Equation (3) predicts pill taking choice without error ($u_{2i} = 0$ for all drivers).
b. Drivers are randomly assigned to pill taking and non-pill taking categories (i.e. $var (u_{1i}) \neq 0$, $var (u_{2i}) \neq 0$, $cov (\omega_i, z_i^*) = 0$ and thus $cov (u_{1i}, u_{2i}) = 0$).
c. Although lifestyle, industry pressures and pill taking choice are correlated in the

driver population [$cov(\omega_i, z_i^*) \neq 0$], there is no correlation between lifestyle/industry pressures and pill taking choice after conditioning on observed X2 [$cov(\omega_i, z_i^* \mid x_2) = cov(u_{1i}, u_{2i}) = 0$ for all drivers].

Requirement (a) is unlikely to be met. Requirements (b) and (c) need to be tested. We cannot impose the assumption that (b) or (c) is satisfied. Given the single-population assumption, if we can assume that the values of β_1 are independent of pill taking choice, then consistent estimates of parameters can be derived as follows:

Implement a pill taking choice model of the binary probit form using maximum likelihood to obtain parameter estimates for β_2:

(8) $$\Pr[z_i = 1] = F(x_{2i}' \beta_2)$$

Given the estimator $\widehat{\beta_2}$, calculate a parameter index

(9) $$\widehat{\theta}_i = -x_{2i}' \widehat{\beta_2}$$

and define the auxiliary or selectivity regressor:

(10) $$\widehat{h}_i = z_i f(\widehat{\theta}_i) / (1 - F(\widehat{\theta}_i)) - (1 - z_i) f(\widehat{\theta}_i) / F(\widehat{\theta}_i)$$

Then include this selectivity term in equation (5), denoting the unknown scaling or parameter of $\rho\sigma_1$ as c, to obtain the selectivity regression:

(11) $$y_i = x_{1i}'^{*} \beta_1 + \alpha z_i + c\widehat{h}_i + \eta_i$$

The parameter estimates in (11) are consistent when OLS is used; however a correction is required to allow for heteroscedastic errors ω_i and η_i unless $\rho = 0$. The correction is implemented in this study to ensure that the standard errors of the OLS model are correct (Greene 1981).

The approach can be extended to more than one endogenous dummy variable and alternative assumptions on the distributions of the unobserved effects in the discrete choice model. In the current context we want to investigate pill consumption and self-imposed schedules, both being observed as discrete binary variates. However, there are two reasonable structural relationships between schedules and drugs:

(i) The first assumes that pill taking and the self-imposition of a schedule are joint (correlated) determinants of the propensity to speed. A bivariate probit model (using starting values from individual binary probit models) is estimated to produce two selectivity regressors.

(ii) The second assumes that the probability of pill taking is conditional on whether a driver has a self-imposed schedule, and that pill taking then directly influences the propensity to speed. A nested logit model is estimated. First the choice of a self-imposed schedule is modelled as a binary logit specification. The probability outcomes are used to construct an index which represents the *expected maximum utility* (EMU) associated with the self-imposition of a schedule conditioning the probability of pill taking. The pill taking logit model is then estimated with the EMU index included as a RHS variable. If the parameter estimate of EMU is not statistically significantly different from unity, then the choice of a self-imposed schedule and pill taking is a joint determination (Hensher 1986). The selectivity term derived from the pill taking model takes a different form to that in the first specification although it has the same interpretation. This arises because the unobserved effects in the logit model have an extreme value type I distribution.

To understand the logit approach as a representation of an alternative behavioural hypothesis, let us consider the case of any number of alternative outcomes. It is a reasonable behavioural hypothesis that truckies act to maximise utility (V), and that they constantly evaluate alternative ways of achieving outcomes (s) consistent with this behavioural postulate. An alternative outcome is chosen if and only if it provides the highest (indirect) utility, that is if:

$$(12)\quad V_s > \max_{\substack{j=1,\dots,M \\ j \neq s}} V_j$$

The probability that alternative s will be chosen is given by:

$$(13)\quad P_s = \text{prob}\,(V_s > \max V_j \ \forall j \in M, j \neq s)$$

Let us define:

$$(14)\quad \eta_s = \max_{\substack{j=1,\dots,M \\ j \neq s}} V_j - \mu_s$$

The alternative s is chosen if and only if $\beta_s' X_s > \eta_s$. The unobserved effects are assumed to be independently and identically distributed extreme value type I. It can be shown that given a vector of exogenous variables, X, the distribution of $F(\eta_s)$ of η_s is:

$$(15) \quad F(\eta_s) = \exp(\eta_s) \Big/ \Big[\exp(\eta_s) + \sum_{\substack{j=1 \\ j \neq s}}^{M} \exp(\beta_j') X \Big]$$

and the probability that the alternative s will be chosen is:

$$(16) \quad P_s = \frac{\exp(\beta_s' X)}{\sum_{j=1}^{M} \exp(\beta_s' X)}$$

This is the multinomial logit model (McFadden 1981, Hensher and Johnson 1981, Greene 1990). To derive the auxiliary regressor, let Φ denote the standard normal distribution function. The transformation $J = \Phi^{-1} F$ proposed by Lee (1983) is strictly increasing, and the transformed random variable η_s^* where $\eta_s^* = J(\eta_s)$ will be a standard normal variate. Since J is a strictly increasing transformation, the alternative s is chosen if, and only if, $J(\beta_s' X) > \eta_s^*$. Since both the random variables ε_s and η_s^* are normally distributed, we assume that ε_s and η_s^* are jointly normally distributed. The specification implies that conditional on the alternative being chosen (Lee 1983):

$$(17) \quad y_s = \gamma_s' z - \sigma_s \rho_s \phi(J(\beta_s' x_s)) / F(\beta_s' x_s) + \xi_s$$

where $E(\xi_s \mid s \text{ is chosen}) = 0$, ϕ is the normal density function, σ_s is the standard deviation of the disturbance ε_s and ρ_s is the correlation coefficient of ε_s and η_s^*. The conditional variance of ξ_s is:

$$(18) \quad \mathrm{var}(\xi_s \mid s \text{ is chosen}) = \sigma_s^2 - (\sigma_s\rho_s)^2 \Big[J(\beta_s' x) + \phi(J(\beta_s' x)) / F(\beta_s' x) \Big] * \phi(J(\beta_s' x)) / F(\beta_s' x).$$

Equation (17) can be estimated in two stages. First we estimate the logit choice model to obtain maximum likelihood parameter estimates for the choice between pill taking and non-pill taking (with the EMU from the self-imposed schedule choice included as a RHS variable). We then estimate equation (19) by OLS after substituting β_j', $j = 1, \ldots, M$ into equation (17):

$$(19) \quad y_s = \gamma_s' z - (\sigma_s\rho_s) \phi(J(\tilde{\beta}_s' x_s)) / F(\tilde{\beta}_s' x_s) + \bar{\xi}_s$$

where: $\bar{\xi}_s = \xi_s + \sigma_s \rho_s \left[\phi(J(\tilde{\beta}_s' x_s)) / F(\tilde{\beta}_s' x_s) - \phi(J(\beta_s' x_s)) / F(\beta_s' x_s) \right]$

The unobserved effects $\bar{\xi}_s$ are heteroscedastic just as they are in the probit specification. A corrected asymptotic variance matrix is constructed to enable OLS estimation to accommodate this correction.

The final empirical results, after extensive testing of hypotheses representing each generic source of potential influence, are summarised in Tables 15 and 16 for the full sample (excluding owner driver fleet operators), and in Table 17 for the trip-specific models for the sub-sample of drivers reporting freight rates. Table 18, at the end of the section, gives the mean and standard deviation of variables used in the models. The data are extremely rich in detail, and because of this we have to be careful to ensure that the selected set of explanatory variables are not subject to collinearity.

6.4 An assessment of the annual economic reward model system

The total number of working hours per annum is the most important truckie-determined factor in establishing the opportunity for economic reward. Hours committed to the job have a significant influence on the amount of driving time obtained which in turn directly contributes to explaining variations in average weekly earnings net of truck expenses. The results are presented in Table 15. Nine exogenous effects were identified as influences on the variations in total working hours across the sample of 791 truck drivers. All are statistically significant and with plausible signs. Hours of work are higher for independent owner drivers, sub-contractors and small company drivers compared to prime contractors and medium/ large company drivers. We found a strong synergy between independent owner drivers and employee drivers employed in companies with less than 6 employees.

Drivers who take pills either some of the time or on all trips tend to work longer hours, as do truckies who have higher annual truck repayments and those who have rejected loads in the past year for whatever reason. Compensating factors which act to reduce work hours are the aging of a truckie and the inclusion of backload provisions where regular contracts are in place. Three additional variables condition the influence of these background, lifestyle, sub-industry status and financial pressure on performance. These are the state in which a driver is based and the incidence of trips between Melbourne and Brisbane. West Australian based drivers tend to work longer hours, all other things being equal, for fairly obvious reasons: they usually have long hauls coast to coast. On the contrary, NSW based truckies tend, relative to drivers based in other states, to work shorter hours. The spatial variables provide an important contextual qualification, highlighting the comparative advantage of NSW based drivers in respect of work hours.

However when one considers the link between working hours and the proportion of such hours which are behind the wheel (directly productive hours if carrying a load) one finds that longer working hours do not lead to a higher percentage of driving time. It does however lead to a higher absolute amount of driving time. This is an important finding because it suggests that in order to improve one's chances of having more wheelhours one has to invest in a more than proportionally higher amount of non-driving time. This is the phenomenon of diseconomies of work time. This is what tends to produce the lifestyle characteristics associated with pills, lack of sleep, self-imposed schedules and bad diet. Three exogenous variables also contribute to the explanation of the variability in the incidence of wheelhours. Truckies with a higher complement of Sydney-Brisbane trips (SBTRIPS), and/or are employee drivers paid per trip (TRIPPY) and/or have regular contracts (RCALL) for all trips tend, other things being equal, to have a higher percentage of work time behind the wheel. This is an intuitively plausible finding. It highlights the important role that regular contracts have in minimising the amount of unproductive or marginally productive non-driving time.

Through the influence of total work hours on the incidence of driving time, there is strong evidence to support the hypothesis that the greater the proportion of work time behind the wheel, the greater the economic rewards, after allowing for a number of contextual, background, lifestyle and other influences. The regular contract (RCALL) features in the direct sources of influence on weekly earnings. Truckies with no regular contracts tend to commit themselves to long periods of waiting to secure the next load. All other things being equal, there is a strong negative and increasingly negative impact on earnings from increasing amounts of waiting time (NXT..). The most noticeable reduction in earnings occurs when waiting exceeds 24 hours (NXTGT24).

Table 15 **Determinants of the annual economic reward profile**
Estimation method: Three Stage Least Squares (791 observations)

Explanatory Variables	Acronym	Parameter estimate	t-value
Equation 1: Log(Av. weekly earnings net of truck expenses) LINCPWKN			
Log(% time driving)	LDRVHRS	0.7860	2.60
Where no regular contract:			
Wait up to 12 hrs for next load (1,0)	NXTL12	-.2180	-2.80
Wait 12-24 hrs for next load (1,0)	NXT1224	-.2397	-2.71
Wait > 24 hrs for next load (1,0)	NXTGT24	-.4377	-4.20
OD years of outstanding loan repayments	OUTLOAN	-.1509	-7.55
Constant		*3.1814*	*2.54*
OLS r-squared		*0.16*	
Equation 2: Log(Incidence of driving time in total work hours) LDRVHRS			
Log(total work hours)	LWORKHRS	-.0878	-1.65
No. of Sydney-Brisbane trips	SBTRIPS	0.0067	3.14
Employee driver paid per trip (1,0)	TRIPPY	0.0748	3.98
All trips with a regular contract (1,0)	RCALL	0.0704	3.29
Constant		*4.4772*	*15.16*
OLS r-squared		*0.10*	
Equation 3: Log(Total work hours) LWORKHRS			
Age of driver	AGE	-0.0067	-5.98
Indep. OD & small co. driver (1,0)	ODINSC	0.0709	3.16
West Australia based (1,0)	WAB	0.1162	2.56
New South Wales based (1,0)	NSWB	-.1548	-7.07
No. of Melbourne-Brisbane trips	MBTRIPS	0.0096	2.56
Pill taking on some or every trip (1,0)	PILLS	0.0681	3.35
Log(annual truck repayments)	LREPAYC	0.0025	1.20
Backload provision for regular contracts (1,0)	BACKLOAD	-.0472	-2.30
Tendency to reject loads (1,0)	REJLOAD	0.0418	1.98
Constant		*4.815*	*98.8*
OLS r-squared		*0.23*	
Equation 4: Number of speeding fines in last 12 months FINES			
Log(total work hours)	LWORKHRS	3.9284	3.82
Pill taking on every trip (1,0)	AWAKE4	1.9051	3.43
Reject loads due to badpayers (1,0)	BADPAY	1.6403	1.70
No. of Sydney-Melbourne trips	SMTRIPS	0.0750	3.64
No. of annual sickdays	SICKDAYS	0.0174	2.10
Constant		*-16.88*	*-3.58*
OLS r-squared		*0.20*	
Equation 5: Number of log book fines in last 12 months FINEL			
Log(total work hours)	LWORKHRS	3.0841	3.74
Pill taking on every trip (1,0)	AWAKE4	1.3075	2.91
Reject loads due to badpayers (1,0)	BADPAY	3.1308	4.01
No. of annual sickdays	SICKDAYS	0.0232	3.45
Constant		*-13.274*	*-3.51*
OLS r-squared		*0.17*	

The financial burden of continuing loan commitments (OUTLOAN) has the expected negative impact on earnings. Owner drivers with a greater number of years of outstanding loan repayments tend to have lower earnings. This might be expected because of the correlation between the number of years of a loan (even allowing for the fact that loans were taken out at different periods prior to the survey period) and the actual repayments, which suggests that all other thing being equal that drivers with longer repayment periods increasingly are unable to keep net earnings up to a level equivalent to those with shorter or no repayment periods.

Two additional equations were linked into the earnings system to establish the existence of possible sources of influence on the number of speeding (FINES) and log book (FINEL) fines. As might be expected the incidence of fines is conditioned by the total amount of wheelhours which are in absolute terms positively correlated with working hours. The incidence of fines is statistically significant on the Sydney-Melbourne route (SMTRIPS) where both the quality of the Hume Highway and the apparently greater police surveillance contribute to explain this situation. Three other factors contribute to the higher amount of annual fines; the consumption of pills (PILLS), experience with bad payments (BADPAY) which has resulted in subsequent rejection of loads and the number of days off work due to sickness (SICKDAYS).

The full model system provides clear evidence to support arguments which suggest that an improvement in earnings may be achieved in an environment of regular contracts (or at least the amount of work time committed to achieving an acceptable earnings stream can be reduced by regular contracts), which flows through to a lesser dependence on pills and loss of business. It does not follow with certainty that a widespread introduction of regular contracts would result in an increase in earnings for all operators. Rather, this will depend on the extent of bidding for contracts which could result in a reduction in rates. The compensating benefit however is the significant reduction in unproductive working hours and the concomitant flow through to improved performance on the road.

6.5 An assessment of the trip specific activity profile

The trip-specific model system results are summarised in Tables 16a and 16b. We begin with the bivariate probit model where we evaluate the extent to which the propensity to take pills and the self-imposition of a schedule jointly influence on-road speed (Table 16a).

Table 16a Determinants of the propensity to speed (total average speed)
Estimation method I: FIML bivariate probit and selectivity regression
(760 observations)

Explanatory Variables	Acronym	Parameter estimate	t-value
Equation 1: Joint determination of propensity to take pills on some or every trip and the propensity to self-impose schedules			
(i) Propensity to self-impose schedules (ARRB)			
Age of driver	AGE	-.091	-1.71
Co. or freight forwarder imposed schedules (1,0)	SCHARR	0.4204	4.26
Independent owner driver (1,0)	ODIOD	0.2365	1.89
No. of stops - sleep + rest activities	SLPREST	-.2031	-2.89
Average ratio drive/total time per trip leg	MEANPERC	0.0102	2.48
Constant		*-.1876*	*-.580*
(ii) Propensity to take pills on some or every trip (PILLS)			
Age of driver	AGE	-.0248	-4.18
Driver has always been a truckie (1,0)	NOPRVOCC	0.3851	3.30
Hours on road in prior 8 hours	ROAD8	0.0471	1.60
Hours sleeping in prior 8 hours	SLEEP8	-.0634	-3.75
Gross weight of truck	TRKWT	0.0402	3.16
Load is perishable cargo (1,0)	GDPER	0.3810	3.39
No. of speeding fines per annum	FINES	0.0850	3.98
Owner driver paid per load (1,0)	PAYTYPL	-.1902	-1.51
All trips with a regular contract (1,0)	RCALL	-.2564	-2.39
Constant		*0.0731*	*0.23*
Rho (ARRB,PILLS)		.0309	0.492
Log-likelihood		-956.25	
Equation 2: Log (Average speed per trip) LTOTASP			
Pill taking behaviour (1,0)	PILLS	0.0815	2.19
Sydney-Brisbane trip (1,0)	SYBR	-.0390	-2.11
Sydney-Melbourne trip (1,0)	SYML	0.0479	3.10
Age of driver	AGE	-.0022	-2.78
No. of no-sleep stops	NOSLEEP	0.0106	2.79
Co. or freight forwarder imposed schedules (1,0)	SCHARR	0.0188	1.50
Percent of trip time 6pm to 6am	EVEPERC	0.0004	1.60
Weekend trip (1,0)	DAYSTRT	0.0379	2.71
Rigid truck (1,0)	TRKRIG	-.1754	-4.58
Log(average ratio drive/total time per trip leg)	LMEANPRC	0.0971	3.33
Lambda (ARRB) - Selectivity		0.0024	0.31
Lambda (PILLS) - Selectivity		-.3180	-1.40
Constant		*3.9687*	*34.27*
Estimated correlation with selection equation ARRB		0.021	
Estimated correlation with selection equation PILLS		-.194	
Estimated disturbance standard deviation		0.164	
r-squared		0.20	

Table 16a continued ...

Equation 3: Log (Standard deviation of speed across legs) LSPEEDSD

Pill taking behaviour (1,0)	PILLS	0.1170	0.80
Sydney-Brisbane trip (1,0)	SYBR	0.1300	1.49
No. of no-sleep stops	NOSLEEP	0.1732	10.03
Trip started before 8 am (1,0)	TSTL8	-.3291	-3.76
Standard deviation of each leg's *drive/total time ratio*	RATIOSD	2.1511	7.85
Lambda (ARRB) - Selectivity		0.0151	0.41
Lambda (PILLS) - Selectivity		0.0507	-.53
Constant		*1.4588*	*12.53*
Estimated correlation with selection equation ARRB		0.021	
Estimated correlation with selection equation PILLS		-.065	
Estimated disturbance standard deviation		0.7900	
r-squared		0.23	

The correlation between the unobserved influences on the probability of pill taking and the self-imposition of schedules is 0.0309. Using the Lagrange multiplier test (LM) under the null hypothesis that rho equals zero (the equivalence of two independent probit equations), the LM statistic value of 3.221 suggests that the hypothesis that rho equals zero cannot be rejected. Thus we would conclude that the bivariate probit specification behaves as if the two choices were independent.

The selectivity terms (Lambda's) in the average speed equation lead us to reject any statistical bias due to the inclusion/exclusion of drivers in each category of the self-imposed schedule treatments (ARRB); however this is not so with respect to pill taking although the confidence level is only 93%. Lambda contains information on the variances of the unobserved components of the probit equation and the selectivity regression equation as well as the correlation between them (Equations 10 and 11). The estimated correlation between the average speed equation and the pill taking equation is - 0.19 and its correlation with the self-imposed schedule equation is 0.021. This evidence suggests that if the self-imposed schedule is to influence average speed, it is unlikely to do so via its joint influence with the propensity to take pills. The possibility of other linkages is evaluated using a nested logit framework under the alternative hypothesis that on-road speed is influenced by pill taking which is itself influenced by self-imposed schedules (Table 16b).

Table 16b Determinants of the propensity to speed (total average speed)
Estimation method II: sequential nested logit and selectivity regression (760 observations)

Explanatory Variables	Acronym	Parameter estimate	t-value
Equation 1: Propensity to self-impose schedules (ARRB)			
Age of driver	AGE	-.0149	-1.76
Co. or freight forwarder imposed schedules (1,0)	SCHARR	0.6871	4.28
Independent owner driver (1,0)	ODIOD	0.3954	1.91
No. of stops: sleep + rest activities	SLPREST	-.3366	-2.64
Average ratio drive/total time per trip leg	MEANPERC	0.0167	2.50
Constant		*-.3114*	*-.60*
Log-likelihood		-497.62	
Equation 2: Propensity to take pills on some or every trip (PILLS)			
Age of driver	AGE	-.0336	-3.40
Driver has always been a truckie (1,0)	NOPRVOCC	0.6302	3.32
Hours on road in prior 8 hours	ROAD8	0.0667	1.28
Hours sleeping in prior 8 hours	SLEEP8	-.1022	-3.67
Gross weight of truck	TRKWT	0.0699	2.66
Load is perishable cargo (1,0)	GDPER	0.5547	2.91
No. of speeding fines per annum	FINES	0.1355	3.45
Owner driver paid per load (1,0)	PAYTYPL	-.3815	-1.78
All trips with a regular contract (1,0)	RCALL	-.3798	-2.13
Expected maximum utility : ARRB	*EMU*	*0.4641*	*2.57*
Constant		*-.3239*	*-0.55*
Log-likelihood		-455.94	
Equation 3: Log (Average speed per trip) LTOTASP			
Pill taking behaviour (1,0)	PILLS	0.0714	1.95
Sydney-Brisbane trip (1,0)	SYBR	-.0304	-2.14
Sydney-Melbourne trip (1,0)	SYML	0.0472	3.06
Age of driver	AGE	-.0024	-3.10
No. of no-sleep stops	NOSLEEP	0.0106	2.78
Co. or freight forwarder imposed schedules (1,0)	SCHARR	0.0167	1.40
Percent of trip time 6pm-6am	EVEPERC	0.0004	1.75
Weekend trip (1,0)	DAYSTRT	0.0381	2.73
Rigid truck (1,0)	TRKRIG	-.1779	-4.68
Log(average ratio drive/total time per trip leg)	LMEANPRC	0.0951	3.23
Lambda (PILLS) - Selectivity		*0-.0246*	*-1.0*
Constant		*3.9863*	*35.09*
Correlation: rho and disturbance		-.151	
Standard error corrected for selection		0.163	
r-squared		*0.20*	

Table 16b continued ....

Equation 4: Log (Standard deviation of speed across legs) LSPEEDSD

Pill taking behaviour	PILLS	0.0733	0.52
Sydney-Brisbane trip (1,0)	SYBR	0.1286	1.50
No. of no-sleep stops	NOSLEEP	0.1725	10.03
Trip started before 8 am (1,0)	TSTL8	-.3354	-3.82
Standard deviation of each leg's drive/total time ratio	RATIOSD	2.1492	7.86
Lambda (PILLS) - *Selectivity*		0.0180	0.19
Constant		*1.4826*	*13.02*
Correlation: rho and disturbance		-.0228	
Standard error corrected for selection		0.788	
r-squared		0.23	

The selectivity regression for the standard deviation of leg speeds (SPEEDSD) was not able to establish a statistically significant link between itself and the two selection equations with respective correlations of 0.021 (ARRB) and -0.065 (PILLS). Given the statistical non-significance of the pill taking endogenous dummy variable we are led to conclude that pill taking behaviour does not influence the variations in average speed between legs of a trip. However, the statistical significance of PILLS in the average speed equation (t-value = 2.19) provides statistically strong evidence to support the hypothesis that after accounting for possible selectivity, the propensity to take pills either on all trips or some trips does have a significant positive influence on trip speed. This important finding reinforces the evidence reported in Hensher and Battellino (1990). The self-imposed schedule dummy variable was statistically non-significant in both selectivity regression equations (with t-values less that 0.08).

The nested logit framework provides a statistically stronger relationship between pill taking, self-imposed schedules and speed. The expected maximum utility index linking the probability of self-imposed schedules and pill taking is statistically significant (t-value = 2.57) and of the correct sign for a nested structure consistent with the notion of random utility maximisation. A necessary and sufficient condition for consistency with utility maximisation is that the parameter of EMU is contained within the range 0.0 to 1.0. An estimated value of 0.46 indicates that there is a sequential recursive relationship between pill taking and self-imposed schedules. The probability of participating in pill taking is amongst other reasons influenced by the expected maximum utility emanating from the choice process associated with self-imposed schedule selection. After allowing for any possible selectivity in respect of pill taking in the population of long distance truck drivers, the evidence supports the hypothesis that there is a positive and statistically significant relationship between pill taking and trip speed. On average, drivers on pills tend, ceteris paribus, to drive at speeds 10 kph greater than drivers not on pills. This is typically a comparison of 90 vs

100 kph and 100 vs 110 kph.

Given the hierarchical linkages now established between speed, drugs and self-imposed schedules, we can interpret the findings on other factors influencing all three endogenous variables. Five exogenous variables had a statistically significant influence on the probability of a driver imposing a schedule. This self-imposition is more likely for younger (and because of its correlation) less experienced drivers. It is reinforced by (or may arise from) the imposition of a schedule from an employer or freight forwarder. Thirty-seven percent of the sample had such a constraint. Independent owner drivers representing 17.4% of the sample have a significantly higher propensity to self-impose schedules than do employee drivers, prime contractors and subcontractors. The analysis also suggests that drivers who tend to have a greater number of trip stops involving some component of sleep and rest (after allowing for the incidence of drive time in total trip time - MEANPERC, which is a highly correlated proxy for trip length) tend to have a lower probability of self-imposing schedules. This arises most plausibly because of the lesser amount of pressure on the driver's earning opportunity.

The factors influencing the probability that a driver will take pills are quite extensive. We consistently found that 9 exogenous variables explained the pill taking propensity within the sampled population. Forty-seven per cent of the sample take pills either all the time or on some trips. Four variables have a negative relationship with the probability of taking pills: the age of the driver, the availability of regular contracts for this trip and all other trips, the opportunity for an owner driver to be paid on a per load basis (in comparison with payment per tonne or per kilometre for owner drivers and either by fixed salary, a percent of truck earnings or on a per trip basis for employee drivers), and the incidence of sleep in the 8 hours prior to trip commencement. The variables that have a positive influence on drug taking are drivers with no previous occupation (who have always been a truckie), hours on the road in the last 8 hours prior to commencing the current trip, the gross weight of the truck (proxying for the size and prestige of vehicles and in many cases debt on the truck), those drivers carrying perishables, and those drivers who tend to have the higher incidence of speeding fines.

These positive and negative influences when taken together are expressing a "lifestyle" phenomenon which in part is the historical product of pressures in the market to secure loads in order to earn an acceptable wage. Any assistance to this industry which can reduce the pressures in the market to a level which will reduce the reliance on pills must be desirable (even after allowing for the possibility of somewhat higher rates for moving goods). The important point is that the current rates have not internalised the negative externalities rampant in this industry, which have spawned a lifestyle encouraging pill taking in order to stay awake long enough to improve the financial situation. The use of stimulants is as widespread in the employee driver sector as it is in the owner driver sector, and is regarded by many drivers as an acceptable practice.

Two empirical measures of speed were used to capture the exposure to risk element of on-road performance. The first is the average speed across all legs (TOTASP), the second is the standard deviation of leg speeds (SPEEDSD). Extensive checking of the data was undertaken to ensure that the reported details on each leg's distance and time (including stop time) were reasonable. Comparisons between drivers on legs between the same locations provided an additional method of checking the reliability of implied speeds. This enabled us to ensure that the distances were accurate and highlighted any substantial discrepancy due to an unreliable reported travel time.

6.6 Key findings

The set of final models contains intuitively plausible findings.

(i) Trip routes and speeding

Ceteris paribus, there is a tendency for drivers on the Sydney-Brisbane route (primarily the Pacific Highway) to have lower average speeds than drivers on other routes. Likewise trips between Sydney and Melbourne (primarily along the Hume Highway) tend to have average speeds higher than the sample average. The first evidence supports the concern to slow down due to the poor condition of the road whereas the higher speeds on the Hume are indicative of the better quality road. Therefore, there is evidence here of the general sensitivity of truck drivers to the quality of the roads. We should also remind ourselves of the evidence that trips along the Hume Highway tend to have a higher incidence of speeding fines.

(ii) Night time driving and speeding

A particularly important finding is that trips with a higher percentage of night-time driving (EVEPERC) are associated with higher average speeds. If this were the only factor influencing the temporal allocation of truck trips, then one may make a case for encouraging more daylight hours of travel. However this has a downside, in that there would be more trucks on the road during hours when more passenger vehicles are on the road. The larger non-rigid trucks tend to have higher speeds than rigid trucks. On average the rigid trucks travel 12 kph slower than the articulated vehicles. It is true however that the trip lengths are shorter for the rigid vehicles. Throughout the study we have noticed a consistent positive correlation between on-road performance and trip length. The strong positive relationship between MEANPERC and average speed (with an elasticity of 0.10) and between RATIOSD and the standard deviation of average leg speed reinforces this point. The option of mandated longer stops (say up to 12 hours) for trips over 500 kilometres is worthy of consideration from an immediate safety perspective. It may have undesirable financial implications because of the likely requirement for a second driver. The TNT Sydney-Albury-Melbourne express freight setup is a good example of safe practice.

(iii) No sleep stops and speeding

Ceteris paribus, drivers with fewer no-sleep stops en route tend to have higher average speeds. This is also linked to the propensity to take pills and the imposition of schedules on 37% of trips by freight forwarders. There is a strong negative relationship between age of driver and average speed, as expected. All of these findings give confidence in the quality of the data - the evidence is intuitively plausible. Most of these influencing variables *individually* affect the average speed 5 kph above or below the average. Thus when combined, there are some substantial variations in average speeds attributable to sets of positive effects as well as sets of negative effects.

(iv) Rates, payment method and speeding

The role of freight rates (or earnings for owner drivers) on trip speed has been incorporated in the trip-specific models for the sub-sample of 410 trips with complete information on rates. We report only the findings for the nested-logit model structure in Table 17. There is very strong evidence to support the primary hypothesis that the trip rate received by the owner driver (i.e. gross earnings) and the freight rate obtained by the company using an employee driver have a significant influence on the propensity to speed. The negative relationship is stronger for owner drivers as might be expected. The relationship with the standard deviation of leg speeds is not statistically significant.

The major impetus of this study has been confirmed: on-road performance is strongly linked to economic reward. An obvious proposition in many ways, but a proposition that has not been previously established in a scientific manner, nor a proposition which has previously been confirmed in the context of allowing for other direct and indirect influences on performance.

Table 17 Linking freight rates to on-road performance
Estimation method II: sequential nested logit and selectivity regression
(410 observations)

Explanatory Variables	Acronym	Parameter estimate	t-value
Equation 1: Propensity to self-impose schedules (ARRB)			
Age of driver	AGE	-.0186	-1.64
Co. or freight forwarder imposed schedules (1,0)	SCHARR	0.3077	1.60
Independent owner driver (1,0)	ODIOD	0.2675	1.40
No. of stops: sleep + rest activities	SLPREST	-.5210	-3.12
Average ratio drive/total time per trip leg	MEANPERC	0.0060	0.64
Constant		*0.7696*	*1.03*
Log-likelihood		-265.22	
Equation 2: Propensity to take pills on some or every trip (PILLS)			
Age of driver	AGE	-.0332	-2.48
Driver has always been a truckie (1,0)	NOPRVOCC	0.5310	1.99
Hours on road in prior 8 hours	ROAD8	0.1481	1.85
Hours sleeping in prior 8 hours	SLEEP8	-.0796	-2.12
Gross weight of truck	TRKWT	0.0542	1.40
Load is perishable cargo (1,0)	GDPER	0.3972	1.53
No. of speeding fines per annum	FINES	0.1131	2.24
Owner driver paid per load (1,0)	PAYTYPL	-.5969	-2.52
All trips with a regular contract (1,0)	RCALL	-.4034	-1.55
Expected maximum utility : ARRB	*EMU*	*0.4556*	*2.00*
Constant		*0.0927*	*0.11*
Log-likelihood		-248.86	
Equation 3: Log (Average Speed per Trip) LTOTASP			
Pill taking behaviour (1,0)	PILLS	0.0743	-1.60
Sydney-Brisbane trip (1,0)	SYBR	-.0587	-2.75
Sydney-Melbourne trip (1,0)	SYML	0.0285	1.50
Age of driver	AGE	-.0029	-3.09
No. of no-sleep stops	NOSLEEP	0.0019	0.42
Co. or freight forwarder imposed schedules (1,0)	SCHARR	0.0395	2.50
Percent trip 6pm to 6am	EVEPERC	0.0068	2.00
Weekend trip (1,0)	DAYSTRT	0.0483	2.73
Rigid truck (1,0)	TRKRIG	-.1014	-1.94
Log(average ratio drive/total time per trip leg)	LMEANPRC	0.0778	1.94
Freight rate for owner drivers (c/km)	*DKMOD*	*-.00087*	*-6.13*
Freight rate for employer (c/km)	*DKMED*	*-.00051*	*-4.00*
Lambda (PILLS) - Selectivity		0.0554	1.72
Constant	*4.2430*	*27.20*	
Correlation: rho and disturbance		0.370	
Standard error corrected for selection		0.149	
r-squared		0.22	

Table 17 continued ...

Equation 4: Log (Standard deviation of speed across legs) LSPEEDSD

Pill taking behaviour	PILLS	0.1987	1.04
Sydney-Brisbane trip (1,0)	SYBR	0.0566	0.58
No. of no-sleep stops	NOSLEEP	0.1148	5.68
Trip started before 8 am (1,0)	TSTL8	-.3046	-2.51
Standard deviation of each leg's drive/total time ratio	RATIOSD	1.3555	3.52
Freight rate for owner drivers (c/km)	*DKMOD*	*-.00071*	*-1.08*
Freight rate for employer (c/km)	*DKMED*	*-.00081*	*-1.37*
Lambda (PILLS) - Selectivity		0.06551	-.53
Constant		*1.9562*	*11.19*
Correlation: rho and disturbance		-.092	
Standard error corrected for selection		0.708	
r-squared		0.15	

6.7 Conclusion

The influences on the performance of long distance truck drivers in Australia are related in a complex way. Although the centrepiece of a causal system is the linkage between potential earnings, lifestyle and pressures imposed on a driver by employers and the marketplace, there are some very explicit influences impinging on safe practices on the road where safety and exposure to risk are adequately represented by variations in average trip speed across the population of truck drivers.

The data obtained from 820 truck drivers are used herein to establish a first round understanding of some of the major endogenous linkages and exogenous determinants on safe practice in respect of a particular trip and its links with the macro environment for annual earnings. This has enabled us to scientifically investigate a large number of the anecdotes and qualitative "evidence" previously used to develop positions in respect of strategies to "rid the industry and the road environment of cowboys".

Table 18 Mean and standard deviation of variables used in the models

DESCRIPTION	ACRONYM	MEAN	STD DEV
Age of driver	AGE	37.50	8.99
Self-imposed arrival time	ARRB	.58	
Pill taking every trip	AWAKE4	.09	
Backload provision for regular contracts	BACKLOAD	.39	
Reject loads due to bad payers	BADPAY	.03	
Weekend start to trip	DAYSTRT	.24	
Percent of trip time 6pm to 6am	EVEPERC *	59.92	26.23
No. of log book fines per annum	FINEL	1.25	3.54
No. of speeding fines per annum	FINES	1.80	4.34
Load is perishable cargo	GDPER	.24	
Log(percent of time driving)	LDRVHRS	4.14	.28
Log(av. ratio drive/total time per trip leg)	LMEANPRC *	4.03	.23
Log(annual truck repayments)	LREPAYC	-2.97	9.06
Log(std dev of trip leg speed)	LSPEEDSD *	2.53	1.85
Log(trip average speed)	LTOTASP *	4.38	.18
Log(total weekly work hours)	LWORKHRS	4.61	.31
No. of Melbourne - Brisbane trips	MBTRIPS	.65	1.45
Av. ratio drive/total time per trip leg	MEANPERC *	57.71	11.64
Driver has always been a truckie	NOPRVOCC	.25	
No. of no sleep stops	NOSLEEP	2.30	1.73
Where no regular contract:			
Wait up to 12 hours for next load	NXTL12 *	.09	
Wait 12-24 hours for next load	NXT1224 *	.07	
Wait > 24 hours for next load	NXTG24 *	.05	
New South Wales based	NSWB	.34	
Independent owner driver	ODIOD	.17	
Independent OD and small co. driver	ODINSC	.42	
Owner driver paid by load	PAYTPL *	.51	
Pill taking on some or every trip	PILLS	.46	
Std dev of each leg's drive/total time ratio	RATIOSD *	.29	.09
All trips with a regular contract	RCALL	.32	
Tendency to reject loads	REJLOAD	.41	
Hours on road in 8 hours prior to trip	ROAD8	.79	1.62
No. of Sydney - Brisbane trips	SBTRIPS	1.02	2.25
Co. or freight forwarder imposed schedules	SCHARR	.36	
No. of annual sick days	SICKDAYS	6.10	18.60
Hours sleeping in 8 hours prior to trip	SLEEP8	2.55	3.06
No. of stops - sleep + rest activities	SLPREST	.30	.63
No. of Sydney - Melbourne trips	SMTRIPS	2.04	3.06
Sydney to Brisbane trip	SYBR	.05	
Sydney to Melbourne trip	SYML	.03	
Employee driver paid per trip	TRIPPY *	.64	
Gross weight of truck	TRKWT	17.05	3.83
Rigid truck	TRKRIG	.03	
Trip started before 8am	TSTL8	.13	
West Australia based	WAB	.05	

Note: Standard deviation is missing for variables coded as (1,0).
* indicates not full sample of 820 trips.

7. SUMMARY OF MAJOR FINDINGS

This final report has described the major variables collected in the survey of 820 long distance truck drivers which was conducted around Australia in September and October 1990. This much larger survey has confirmed many of the findings of the pilot survey which was conducted in Sydney in August 1989, as well as contributing additional evidence. The data has been analysed at a descriptive level where frequencies of all variables and cross tabulations of some of the key variables have been examined and at a highly complex level using econometric modelling. Some of the main findings from the descriptive analysis are summarised below.

* the majority of truck drivers (70%) had over 10 years experience driving large trucks on a regular basis.
* the average number of annual vehicle kilometres driven by drivers in the sample was around 200,000 kms.
* the majority of drivers (75%) were in the age group 25 to 44 years.
* 25% of drivers had no previous occupation other than truck driving. For the others a range of occupations was represented, primarily the trades, farmers and general labourers, but also a significant number of managerial and professional positions.
* the survey highlighted the low level of income earned by drivers, particularly owner drivers (36% earned less than $15,000 in 1989-90).
* drivers believed that they worked an average of 105 hours per week. This included all work activities both on and off the road. Of this, about 65% on average was estimated to be driving time.
* 40% of trucks were less than 3 years old. Owner drivers were more likely to have older trucks than any of the other types of driver.
* the high cost of the commitment of financing the truck was highlighted by the low level of deposit of most owner drivers and the short period of the loan. The average loan period was 4.25 years and average monthly repayments were around $2,500.
* repayments on the truck were the second highest component (after fuel) of total expenses for owner drivers.
* the majority of employee drivers (79%) were paid directly in relation to the earnings of the truck.
* the main issues confronting the industry mentioned by drivers were the low level of freight rates relative to their operating costs and the high cost of fuel and taxes.

* drivers from small companies recorded the highest average trip speed for the sampled trip (82.01 kph compared with the average for the sample of 81.06 kph).
* a higher average trip speed for the sampled trip was found on the longer trips.
* the younger, less experienced drivers recorded the highest average trip speed on the sampled trip (those driving for less than 5 years had an average speed of 82.14 kph and those aged 17-24 years of age had an average speed of 84.72 kph compared with a sample average of 81.06 kph).
* at the time of the survey (September - October 1990) 13% of drivers were driving trucks which were fitted with a speed limiter. This varied greatly by type of driver with 42% of large company trucks being speed limited.
* 19% of drivers were driving trucks which had a tachograph fitted.
* approximately 35% of all drivers were travelling to a set schedule for the sampled trip.
* but 60% of drivers maintained that even if they were not set a schedule by the freight forwarder they were aiming for their own self-imposed time of arrival. This was dictated primarily by concerns to be first in the queue to be unloaded and then to obtain the next load.
* a considerable amount of time is spent by drivers in off-road work activities before embarking on the trip. Approximately 3.5 hours were spent on work related activities, such as unloading from a previous trip, loading for the next trip and maintenance of the truck, before beginning to drive.
* 46% of drivers admitted to taking stimulant drugs at least on some trips.
* the most important factors which drivers considered contributed to crashes involving heavy vehicles were the condition of the roads, the behaviour of other vehicle drivers, fatigue on the part of the truck driver and lack of driving skills by the truck driver.
* 17% of drivers had been involved in a crash in the 2 years preceding the survey. Owner drivers and small company drivers were more likely to have been involved in more crashes than the other types of driver.
* drivers were very supportive of the need for specialised driver training courses to upgrade the skills of truck drivers and to improve their image with the general public. 80% of drivers were in favour of introducing driver training courses.

In the pilot study a simple regression model was used to analyse the possible factors which influence drivers to speed. However, because of the high level of multi-collinearity between the variables a single equation multiple regression model is not appropriate for analysis of the much larger and richer data set of the main survey.

The analysis of the main survey data required a complex set of structural equations to be developed to represent the two-way causality inherent in the sources of influence on the driver's behaviour on the road. Given the nature of the interrelationships between the propensity to speed, the economic pressures in the industry, lifestyle attributes and backgrounds of truck drivers, a multivariate statistical analysis is required if we are to separate out the influences on on-road performance.

The major findings from the econometric analysis include:

1. Economic rewards to both owner drivers and employers of drivers have a major influence on the propensity to speed; but that in particular:

   (i) it is the rate per se which acts to stimulate road practices in various forms in order to ensure that an acceptable level of total earnings (net of truck-related expenses) is obtained. Any deviation from a fixed salary tends to encourage practices designed to increase economic reward which are not synergetic with reducing exposure to risk.

   (ii) the uncertainty of annual earnings encourages the practice of self-imposed schedules and the taking of stimulants to enable extension of the productive working week. While the extended working week does increase the earnings, the incidence of productive (i.e. driving) time decreases as total working hours increases. Any strategy which can reduce the uncertainty of earnings must reduce the hours of total work, increase the amount of sleep time and consequently reduce the incidence of self-imposed schedules and hence the use of stimulants.

2. Regular contracts are a preferred form of load allocation, initially obtained by a process of competitive bidding, with possibly relatively short contracts in order to ensure that bid prices remain competitive. This may be the only way to minimise the amount of unproductive waiting time and to eventually prune the industry. Major implementation of competitive bidding in other transport industries is seen as a preferred alternative to complete economic deregulation primarily because of the inability of deregulation to manifest an acceptable program of internalising the negative externalities of unfettered competition.

3. Loan repayments on a truck are a major financial commitment of owner drivers. Thus strategies to ensure that the financing of trucks is achieved with least burden must improve the net earnings of the owner driver sector.

4. The anecdotal evidence which tends to lay the blame for bad on-road behaviour on owner drivers is fallacious. Small company employee drivers have some of the worst industry practices in respect of speeding, use of stimulants and incidence of fines. Indeed many of the influences on variations in on-road performance, pill taking and self-imposition of schedules which often lead to speeding are not correlated with whether a driver is an owner driver or an employee driver. The distinction between owner driver and employee driver is somewhat arbitrary and misleading in the current context. A much more useful classification is in terms of the nature of contracts.

5. Lifestyle factors appear to have evolved as a result of the ease of entry to the industry coupled with its highly competitive nature which demands non-routine and unpredictable work practices for a significant number of drivers in the industry. There appears to be a case for much more stringent safety regulations centred on the health of the driver as distinct from the "health of the rig". There is a great temptation for commentators to argue that if someone wants to enter this industry, get burdened with high debts and work excessive hours to "make a quid" then they should be allowed to. This may be acceptable wisdom if safety of human resources at large were not at risk. It is precisely because of the negative externalities aligned to safety that changes are required in the competitive practices in the industry. The transactions costs are sufficiently high to warrant some restrictions on competitive practices *in* the market. Competition *for* the market should be given serious consideration.

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