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The Utilisation of Commercial Vehicles in Urban Areas

by

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ABSTRACT: This paper examines the utilisation of commercial vehicles in the greater Sydney metropolitan region. It is based on an analysis of data from the 1991/92 Commercial Vehicle Survey (CVS) undertaken by the Transport Data Centre at the Department of Transport in New South Wales, Australia. This survey provides *prima facie* evidence that vehicle productivity could be improved. Data is presented on the proportion of the vehicles working on an average week day, the average number of trips made on any one day and the average time spent travelling each day. Notwithstanding the fact that the results could be biased due to survey response factors and the knowledge that there was a recession in 1991/92, the values for these indices are relatively low. The paper considers possible reasons for the low level of vehicle utilisation and the implications for road network planning and logistics management.

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INTRODUCTION

This paper investigates urban goods movement in Sydney, Australia, with particular emphasis on the apparent efficiencies, or lack of efficiencies, of the road freight system as a whole. It is based on analyses of the results of a commercial vehicle survey (CVS) undertaken in Sydney in 1991/92. It examines the interaction between logistics and the road network, and the implications for policy and planning. The paper also investigates the variability of data, and considers how the quality of survey data could be improved in future.

Improving the efficiency of goods movement can greatly assist regional growth and prosperity. Goods vehicles travel on roads which have been designed primarily for the movement of cars. Operators of these vehicles have tended to focus on short-term profitability and competitiveness. Longer term measures to improve the road freight system have generally had a lower priority. This is particularly so for small and medium-sized freight operators with limited resources. However, with increased professionalism and higher levels of education in the road freight industry there is a greater tendency to invest time in understanding both the industry, and methods of improving efficiency.

Several studies around the world have found that establishing plants and warehouses at strategic locations can yield significant saving both for companies and the wider community, permitting better access to both domestic and export markets (Reilly and Hochmuth 1990, Cristie et al 1977, Road Construction Authority 1987). Congestion management, traffic management, travel demand management and incident detection also help to ensure that the road system is operating productively.

Contrary to what some people think, trucks generally have little impact on overall vehicle congestion at peak periods (Grenzeback et al 1990). On the other hand, service vehicles, which in this paper will be called 'light commercial vehicles'[1], have a much larger impact on total vehicle congestion, as a result of their much greater numbers. The service industries are accounting for an increasing proportion of economic growth and employment opportunities. In Australia over the last 20 years the number of service vehicles on register has almost doubled, compared to an increase in articulated vehicles of 30 percent and an increase of 10 percent in rigid vehicles (Australian Bureau of Statistics 1992).

Remembering that freight movement is a derivative of other industries, transport must be viewed in the context of the whole production process. Transport decisions can be dictated by savings or requirements elsewhere in the production chain, possibly resulting in less efficient transport operations. Therefore, while traffic engineering and management strategies are pursued to improve network efficiency, the logistical strategies of businesses also need to be considered in the overall equation.

INTERACTION BETWEEEN FREIGHT TRANSPORT AND OTHER ACTIVITIES

In broad terms there is a significant correlation between economic activity and the amount of freight moved (Taplin 1983). The urban freight system is strongly related both to contemporary management styles and other aspects of the urban system, such as the urban

[1] In the survey, the term 'light commercial vehicles' referred to goods vans, utilities (pick-ups) or 4 wheel-drive vehicles and excluded commercially-registered station wagons and sedans.

passenger movement, the inter-urban freight system, land use, regional development, aspects of the physical and social environment, and employment (Ogden 1992). Consequently there are many factors which influence patterns of freight movement patterns: eg.

- logistical practices such as quick response, supply chain management, just-in-time, right-on-time,
- labour practices
- nature of consolidation/deconsolidation points,
- geometric structure of the road network, and
- government and council regulations affecting, *inter alia*, vehicle access, mass and dimension limits, and restrictions to night-time movement.

Commercial vehicle movement and the logistics chain

Many firms, especially in the manufacturing sector, now manage their freight transport within a logistics management context (Gilmour 1987, Cox and Meyrick 1994, Ogden 1995). This means that decisions about freight transport are not made solely on the basis of transport variables and marketing strategies but also with respect to other factors, such as the outsourcing of components and scheduling of inbound inventory. The nature of freight movement is therefore influenced by costs and variables elsewhere in the supply chain. For example, the availability of cheaper power in Victoria than in the island state of Tasmania might result in the re-location of a major plant, reducing the need for freight movement across the Bass Strait.

One of the most important logistical trends has been the downward pressure on inventory levels, resulting in supplies being delivered more frequently and in smaller quantities (Harutoshi 1994, ter Brugge 1991). An example of this is in Japan where ‘the average mass carried on each trip fell by 36 percent, from 3.8 tons in 1980 to 2.4 tons in 1990’ (Harutoshi 1994). No comparable figures are available for Australia, though it is believed that this is a world wide trend. The impact of this logistical trend on the transport system is not well understood.

The Effect of Congestion on Business Location.

As congestion escalates, transport costs increase and pressure is exerted on business to move to a cheaper locations and find new opportunities (Municipality of Metropolitan Toronto 1987). It is likely to be industries with the lowest value-added that move out of a congested area first. Some service industries have a high resistance to being pushed out of an area, as illustrated by the thriving service sectors in congested cities like New York, London and Paris. The retailing has a medium-level of resistance, with some dispersal of retail capacity to regional/suburban shopping centres. On the other hand, heavy industry and manufacturing industries tend to be the first to leave an urban area when it becomes congested (Municipality of Metropolitan Toronto 1987, Rawling 1989).

By keeping businesses informed of how the arterial network will develop, municipal authorities can help them plan expansions and relocations more efficiently and effectively. This knowledge can be incorporated into the logistical decision-making process. Furthermore, the use of intelligent transport systems (ITS), which provides drivers, operators, and customers with real time traffic information, can help firms minimise the impact of congestion (Ogden 1993).

SYDNEY COMMERCIAL VEHICLE SURVEY

The commercial vehicle survey (CVS) undertaken by the Transport Data Centre in Sydney, Australia, used mail-out mail-back questionnaires to collect data on the activities of commercial vehicles registered in Greater Sydney. A total of 9,946 questionnaires were returned providing data on 24,882 trips across three vehicle classes; light, rigid and articulated vehicles. The greater Sydney urban region comprises the 'provincial' centres of Newcastle and Wollongong and extends west to the Blue Mountains (see Figure 1). Further information on the CVS methodology and analysis can be found in Maldonado and Akers (1992) and Taylor (1997) respectively.

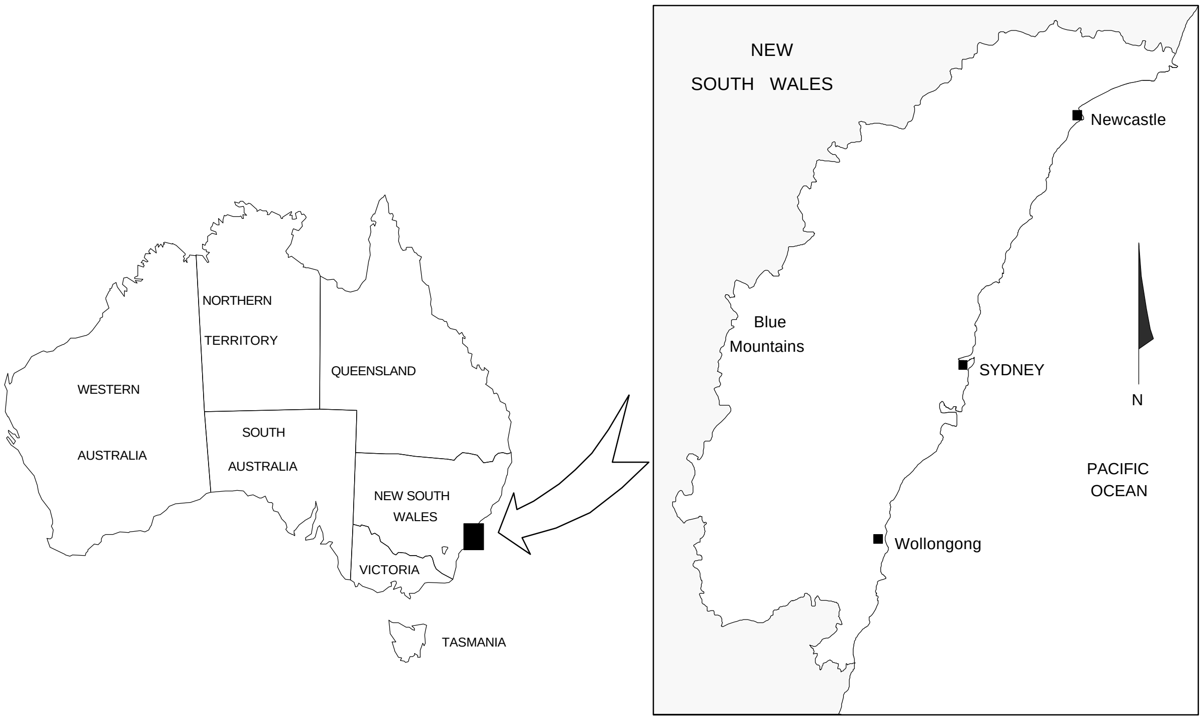

Figure 1 Greater Sydney metropolitan region (study area)

For the purposes of this paper analysis is restricted to intra-urban trips, or trips with both ends within the greater Sydney region, where a trip is defined as a one way movement from origin to destination.

Data were provided by the drivers and included origin and destination, travel time, distance travelled, idle time, time of day, and so on. Data were generally highly variable and the spread of trips was very large indeed. This was mostly due to the inherently variable nature of commercial transport but was also due to the low response rate in parts of the survey, which is typical of mail-out mail-back freight movement surveys (Lau 1995).

Accuracy of survey results

The large spread of data is illustrated by the box and whisker plot in Figure 2 (Taylor 1997). The top and bottom of the rectangle indicates the lower and upper quartiles (25%le and 75%le respectively) while the vertical lines (whiskers) which extend from the ends of the rectangle depend on the interquartile range (1.5×IQR). The median is marked inside the rectangle with a bold line while the mean is shown by a dashed line. Usually the individual data points which do not fall within the box and whisker range are also plotted, but for reasons of scale these values are not shown here, suffice to say that values were reported over the whole permissible range.

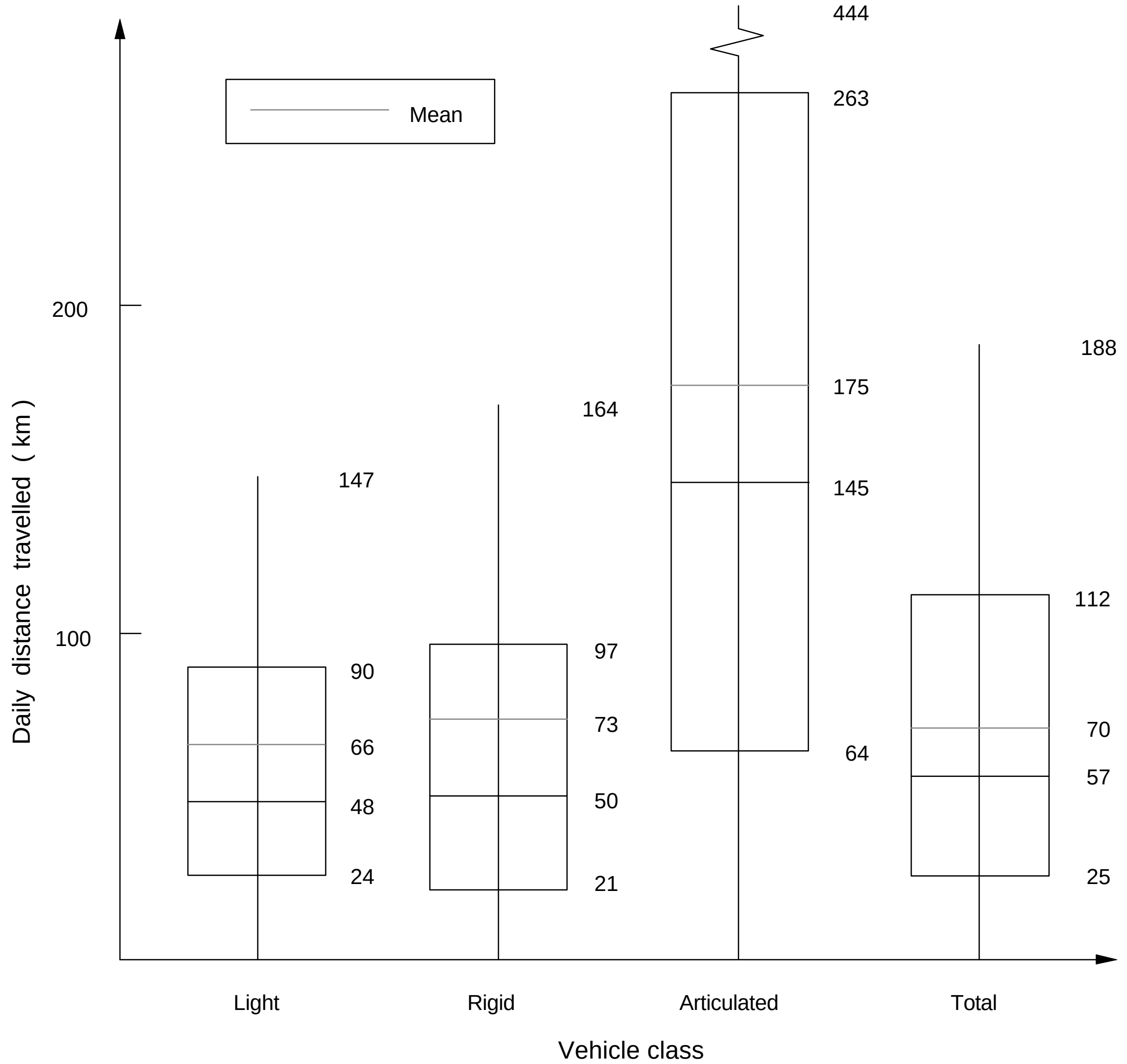

Figure 2 Example of box and whisker plot: daily distance travelled

A low response rate leads to a smaller sample size and combined with high variability this can lead to lower confidence in the results. To estimate the error in the individual characteristics reported, the sampling error or standard error (SE) is used, and is expressed as a percentage (relative standard error, RSE[2]). The sampling error is defined as the difference between the population mean and the sample mean. Where RSEs are high, comparisons between estimates need to be made cautiously as some differences may be due more to data variability than to actual differences between categories.

While the degree of uncertainty associated with the results of surveys such as this may be higher than desirable, transport profession often overlooks the sampling errors or alternatively does not publish the results. It is important to identify areas where high variability exists because this information is extremely useful in the design of future surveys, especially those using ‘optimal allocation’. Optimal allocation is a statistical process which can only be used when there is previous data available and uses revealed variability of each stratum to determine appropriate sample sizes.

The CVS results discussed in subsequent sections of this paper refer to mean and median values. It is important to keep in mind that these mean and median values usually represent a very wide range of reported values, as illustrated in Figure 2,

UTILISATION OF COMMERCIAL VEHICLES

Table 1 shows the proportion of vehicles which made at least one trip on a weekday in the greater Sydney (urban) area. At best it indicates that two thirds of the fleet were used, or made at least one trip, on an average weekday. Utilisation appeared even lower when viewed in conjunction with the average daily travel time, which indicates that vehicles spend less than four hours a day travelling, depending on the size of the vehicle (Table 1). It is not possible to explain this under-utilisation without knowledge of how organisations run their fleets, however one can identify several possible reasons:

- vehicles unloading and or loading (no data was collected on vehicle activities, such as queuing or waiting while idle, apart from whether stopping to pick-up or deliver),
- vehicles being repaired, (although discussions with vehicle operators indicate that the proportion of the fleet being repaired was less than 10 percent and much lower for hire and reward operations),
- the recession. In 1991/92, Australia was still in the depths of a recession, and given the close relationship between economic activity and freight movement, it is likely that the drop in activity meant less vehicles were required[3],

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[2] Relative Standard Error (RSE) or sampling error is defined as the difference between the sample mean and population mean. The mathematical formula is:

$$RSE(\%) = \left(\sqrt{\frac{\mathrm{var}(sample) \times (1 - n/N)}{n}} \right) \div mean(sample) \times 100$$

[3] In Australia, GDP decreased by almost 1% in 1990-91 and 1992 (Australian Bureau of Statistics 1995). This decline in economic activity is likely to have reduced the number of truck trips required. This is further supported by data on distillate sales to the transport sector. This shows that sales of automotive distillate oil (ADO) had been increasing since 1973, but fell during the 1990-2 period (Australian Bureau of Agriculture and Resource Economics 1993). ADO is the main fuel for trucks, representing 100% of the fuel used by articulated vehicles and 60% of that used by rigid vehicles registered in the Greater Sydney region (Table 4.5.1). The Australian Bureau of Agriculture and Resource Economics (1993) quoted that the reduction in sales was mainly due to the decline in road freight activity, however this was not supported by quantitative data.

- inadequate work available for the vehicle, especially for special purpose vehicles such as tow trucks, earth moving or special equipment/apparatus vehicles, and ancillary vehicles like fruit and vegetable trucks. In the case of port-related traffic, utilisation partly depends on the frequency and cargo of ships arriving and departing (Maritime Services Board 1993),
- large vehicles tend to be older and, though no longer used for long hauls, may be adequate for urban goods movement. As they are largely depreciated, operators are under less financial pressure to maximise their utilisation.
- on the whole, vehicle owners and operators may not be aware of the extent of their fleets under-utilisation. If this is a factor, it is likely to change as the transport sector becomes more professional. Increasingly, businesses and freight firms are employing tertiary educated people, and drivers are expected to perform a range of tasks such as final assembly / installation and customer support.

TABLE I
VEHICLE USAGE PATTERNS PER VEHICLE (WEEKDAYS)

	Light	**Rigid**	**Articulated**	**Total**
Daily distance travelled (km)				
mean	66	73	175	70
median	48	50	145	57
RSE (%)	±33%	±8%	±7%	±9%
Daily travel time (h:min)				
mean	1:45	2:01	3:59	1:52
median	1:24	1:30	3:35	1:40
RSE (%)	±30%	±6%	±5%	±8%
Daily idle time (h:min)				
mean	5:35	4:32	3:31	5:16
median	6:08	4:15	3:00	4:17
RSE (%)	±24%	±6%	±6%	±7%
Working Vehicles#	64%	58%	52%	62%
No. vehicles in sample	1058	2945	757	4760

Source: 1991/92 CVS

\# Working vehicles are the average proportion of vehicles that make at least one trip within the study area, on an average day.

RSE - Relative Standard Error; $RSE(\%) = \left(\sqrt{\frac{\text{var}(sample) \times (1 - n/N)}{n}} \right) \div mean(sample) \times 100$

To explain this apparent under-utilisation fully, it would be necessary to investigate each firm's objectives. These could be identified in terms of marketing strategies, logistics management, fluctuations in customer demand (for example, higher demand in the morning), the split between vehicles operating under hire and reward conditions and those operating on an own-account basis.

Pattern of collection and delivery.

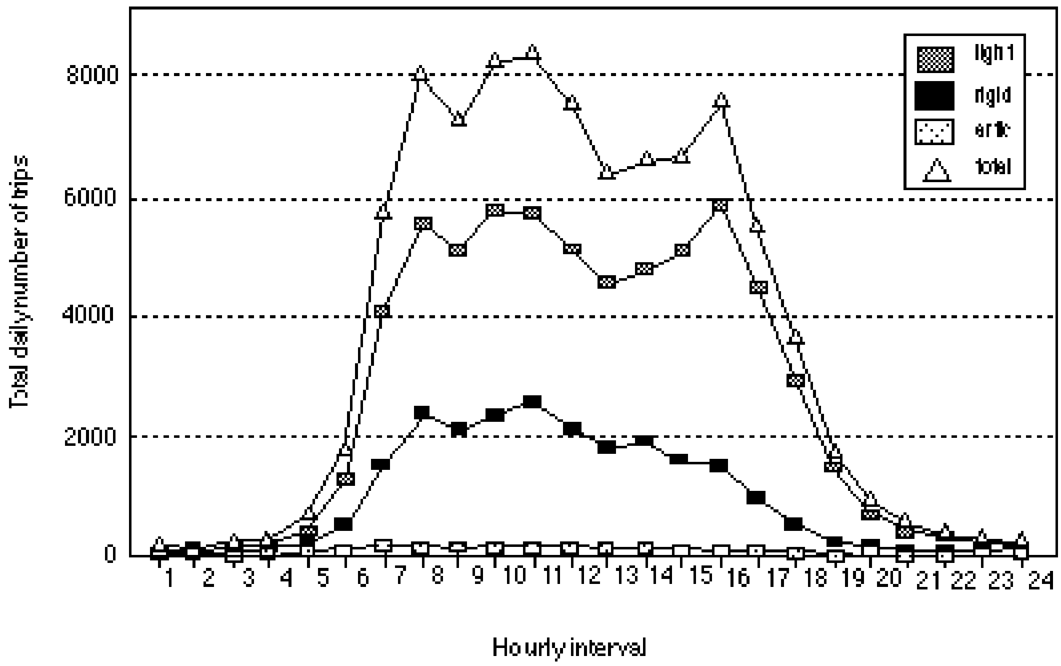
Across all vehicle classes, deliveries of goods were about twice as frequent as collections. By vehicle class, articulated trucks performed a lower proportion of deliveries than the other vehicle classes, indicating a tendency toward fuller truck loads.

In looking at the nature of vehicle stops, Table 2 shows the proportions of deliveries or pick-ups made throughout the day, split into morning, afternoon and night-time periods. As expected, different sized vehicles serve different markets and accordingly have discrete collection and delivery characteristics. Generally articulated vehicles made more deliveries and pick-ups in the morning than light or rigid vehicles, which is probably a function of the temporal distribution. (Articulated vehicles begin working earlier than other vehicles.) Light vehicles made between a half and a third of their stops in the afternoon. Conversely the majority of the stops at which there were no deliveries or collections occurred in the afternoon. Again this is consistent with Figure 3 which shows that most of the work is done in the morning (see next section).

TABLE 2
DISTRIBUTION OF STOPS BY PURPOSE AND TIME OF DAY (WEEKDAYS)
EXPRESSED AS A PERCENTAGE OF TOTAL STOPS

	Deliveries (%)			Pick-ups (%)			Pick-ups & Del's at same stop (%)			No pick-ups or Deliveries (%)		
Arrival Time	Light	Rigid	Artic.	Light	Rigid	Artic.	Light	Rigid	Artic.	Light	Rigid	Artic.
5am-12noon	55	65	66	57	67	68	53	67	65	47	45	30
12noon-6pm	41	32	28	38	29	25	42	28	25	45	49	60
6pm-5am	4	3	6	5	4	7	5	4	10	8	6	10
Total	100	100	100	100	100	100	100	100	100	100	100	100

Source: 1991-92 CVS



Source: 1991/92 CVS

Figure 3 Distribution of trip start times on weekdays

DAILY TEMPORAL MOVEMENTS

Hourly fluctuations in vehicle movements

Figure 3 shows the relative frequencies of commercial vehicle trips on the greater Sydney network at hourly intervals (Taylor, Maldonado and Ogden 1994). Commercial vehicle movements started increasing at around 6am, and peaked mid morning, between 10am and 11am, before dropping to a day-time low at 12.30pm. It should be noted that although there are relative peaks and troughs, compared to the temporal distribution of passenger cars, commercial travel is considered to be fairly constant throughout the day.

Activity increased slightly after the midday period until about 3.30pm when the number of trips starting began to drop to coincide with the end of the 'trade' working day. Light vehicles appear to exhibit slightly different temporal patterns from the other types of vehicle. After the midday period, light vehicle activity increased again whereas the other vehicles began to taper off until the end of the working day. It can take a long time to unload or load a large vehicle, and sometimes the vehicle is loaded in the afternoon in preparation for the next shift (often the following morning). This means that drivers may need to finish their trips in the early afternoon so that the vehicle can be reloaded before the end of the day. Moreover, organisations often refuse to receive goods after 3pm.

It is interesting to note that analysis of trip start times reported in the 1991/92 Home Interview Survey, which surveys person travel patterns in the CVS study area, shows some similarities between person and commercial vehicle travel. Weekday peaks for commuters are at 8am and 3pm, and 'local' peaks for commercial vehicle trips are at about 7.30am and 3.30pm (Transport Study Group 1994) (Table 2).

Tendency for commercial vehicles to avoid peak periods?

Intuitively one might assume that almost all vehicles start in the morning, but how early do they start, and do vehicles deliberately avoid the peak period? Table 3 illustrates the trip start times of first trips and shows the cumulative proportion of trips started prior to 7am, and prior to 8am. Sixty-four percent of articulated vehicles started their first trip before 7am, while 36 percent of light vehicles started before 7am. In other words, larger vehicles tended to begin their first trips earlier in the morning. By 8am, 85 percent of articulated vehicles had started their working day (Table 3 and Figure 3). A similar result was found in a study in New York and New Jersey which concluded that over 35 percent of trucks made trips during the morning peak (6am to 10am) (Lau 1995).

TABLE 3
START TIME OF FIRST TRIP (WEEKDAYS)

	Cumulative frequency (%)		
Time period	**Light**	**Rigid**	**Articulated**
midnight - 3:59	1.4	2.3	6.7
4:00 - 4:59	3.1	5.3	15.4
5:00 - 5:59	10.7	14.1	36.3
6:00 - 6:59	36.0	41.1	64.3
7:00 - 7:59	65.8	70.6	85.2
8:00 - 8:59	82.8	83.4	89.2
9:00 - 9:59	90.1	89.7	92.2
10:00 - 10:59	94.1	93.8	94.1
11:00 - 11:59	95.8	95.4	96.2
noon - midnight	100.0	100.0	100.0

Source: 1991-92 CVS

One reason for the importance of the morning peak to commercial vehicles could be the high incidence of customer-specified delivery times. Customers often require deliveries at certain times, particularly early in the day, so they can receive and use the stock throughout the day. For example, in Tokyo in 1986, 44 percent of trips stipulated an exact arrival time, 35 percent stipulated a morning or afternoon arrival time, and 17 percent designated a delivery day (Harutoshi 1994). Temporal patterns of commercial vehicle movement are largely a reflection of customers' requirements. Meeting these requirements may meet business objectives, but it can have negative social and environmental effects through increased congestion and emissions, especially as a result of higher delivery frequency.

As a corollary, there are significant implications for the management of the road system throughout the day but particularly at peak periods. Appropriate traffic management, incident detection, and travel demand management including innovative and flexible public transport systems are all significant factors in ensuring that the road network performs at its best.

CONCLUSIONS

Improvements in logistics management has raised the efficiency of individual firms but this could be at the expense of the productivity of both the freight transport industry and urban freight system. In turn, this could result in adverse impacts such as increased externalities and social costs through increases in travel due to, say, more frequent deliveries. Therefore there is a need for firms to take more account of government plans for network development and regulation in the design and management of their logistical systems. Equally, policy makers need to improve their understanding of the factors affecting commercial vehicle movement in urban areas..

The Sydney CVS showed that on average commercial vehicles spend less than half of the working day on the road, even less for smaller vehicles, and only two-thirds of the fleet is used on an average weekday (Table 1). *Prima facie,* this suggests that there is room for efficiency gains in commercial vehicle operations. On the other hand, given that demand for freight transport is derived from other economic activity, it is possible that firms are trading-off lower vehicle utilisation for greater efficiency in other activities elsewhere in the supply chain. Analysis of these trade-offs is beyond the scope of this research and is an area of future investigation.

Further, the morning peak period is extremely important to urban goods movement and it is likely that customers are influencing this (Table 3 and Figure 3). On the other hand, the traditional practices of trucking operators and drivers should not be under-estimated. Traditionally, the wholesale and retail trades have tended to dispatch and receive loads earlier in the day.

In summary:

- The formulation of freight policy needs to be considered within the wider contexts of urban transport policy and logistics management. Optimising a business logistics system independently of measures to improve the efficiency of the urban road network will not necessarily lead to optimisation of the entire urban freight system.
- As the morning peak period is important to commercial vehicles, connectivity and traffic management (eg incident detection) are critical to vehicle efficiency and productivity at this time.
- Restrictions and regulation need to be considered as part of an overall plan, with adequate investigation of the logistical implications.
- Publishing results of surveys, particularly where there is a dearth of information, is vital if the state of knowledge in urban freight data collection is to be enhanced. Even if results are less than ideal, the profession should make an effort to publish. There is always much more to be learned from so called failures than from successes.
- Optimal allocation be used in future surveys. The experience of the CVS indicates that light commercial vehicles have quite different survey response rates and characteristics from heavier vehicles. Light vehicles seem to exhibit characteristics which are more comparable with passenger vehicles than with trucks.
- The CVS provides information specifically provided by the driver of the vehicle and is therefore limited by the drivers' knowledge and experience. To build on this base and to gain more insight into urban delivery operations it would be useful to supplement the CVS with interviews with managers of freight companies, manufacturing plants and other businesses.
- Intelligent Transport Systems (ITS) could greatly enhance the state of knowledge by making data collection simpler, less time consuming and less intrusive. The increasing availability and affordability of vehicle tagging, responders, interrogators, and scanners

enables vehicles to be tracked in real time. This has potential not only for data collection but also for improvements in total transport system productivity and safety.

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