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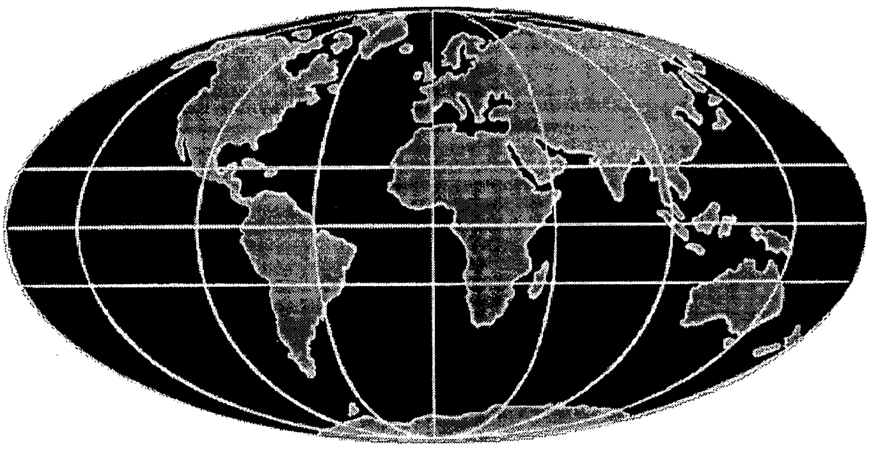

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SYNOPSIS

Truck journey time savings can represent an important component of the benefits of investment in main roads. However, there has been disagreement, amongst various authors, about the extent to which vehicle time savings can be used fully by being translated into extra trips. A vehicle utilisation survey was carried out in Pakistan during 1985-86. Different vehicle activities were timed and recorded on a continuous basis for periods lasting from five days to four weeks. It was found that freight vehicles were in active use (travelling, loading, and unloading) for more than 12 hours per day. From the data a series of elasticities were calculated relating trips to travel time and these showed that, in Pakistan's conditions, time savings following road investment, are likely to be used fully.

CONTENTS

1. INTRODUCTION

The rapid growth in traffic volumes experienced by many developing countries has, in recent years, led to increasing interest in providing high capacity roads that are primarily designed to reduce congestion and provide journey time savings. Although time savings can represent a major part of the benefits of road investment, the area has attracted comparatively little research in developing countries. This is especially true for freight transport which often forms a substantial proportion of long distance traffic.

Important components of truck operating costs (particularly the capital costs, labour costs and overheads) are time dependent. To appraise correctly high capacity, high speed roads it is necessary to value the savings in costs of these time dependent components. To do this correctly it is necessary both to measure the amount of time a vehicle spends working (i.e. moving, loading and unloading) and to make predictions about the extent to which potential time savings may be translated into productive use.

Commonsense might suggest that if road investment brings about journey time savings then, on average, trucks should be able to make full use of the time saved by making extra trips. However, there has been disagreement, amongst various authors, about the extent to which this can be achieved. Some studies have even suggested that a large part of time savings cannot be used readily.

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Recently, a study of Pakistan's trucking industry was undertaken by the Overseas Unit of the Transport and Road Research Laboratory (TRRL), UK in cooperation with the National Transport Research Centre (NTRC), Pakistan. As part of the study a survey of vehicle time utilisation was carried out. An analysis of the results of this survey are presented in this Paper. Other published reports and Papers relating to the study are listed in the references.

2. THE VALUATION OF COMMERCIAL VEHICLE TIME SAVINGS

In order to value the benefits of journey time savings for commercial vehicles arising from road investment, it is necessary to make assumptions or predictions about the extent to which the potential time savings may be translated into productive use. Some authors, such as Dawson and Vass (1974), assume constant working hours per year in their formulation of vehicle operating costs; this implies that, following a road investment, all time savings will be fully used and that the value of time (for all time dependent costs) will remain unchanged, per unit of working time. With these assumptions time savings benefits may be simply calculated from the predicted time saved and the value of vehicle and crew working time.

A common approach is to relate annual time costs to the distance travelled per year. Time savings benefits are then calculated by predicting a change in the annual distance travelled. This may be estimated either by a formula derived from vehicle speed or estimated by the user. Neither procedure is very satisfactory. For example both Winfrey (1969) and De Weille (1966) have proposed a formula from which it can be calculated that a one per cent decline in travel time would bring about a one per cent increase in distance travelled. It is assumed that the time spent travelling per day will remain constant. The assumption of constant travelling time is clearly unrealistic for commercial vehicles where loading and unloading time is an important component of the working day. This approach will nearly always tend to overestimate time savings benefits.

Other vehicle operating cost model formulations (such as TRRL's 'Road Transport Investment Model', the Central Road Research Institute's 'Road User Cost Study in India', or the World Bank's 'Highway Design and Maintenance Standards Model') provide the user with the option to predict utilisation following road investment or to choose one of a variety of models to achieve the same result.

The assumption that travel time savings can be readily translated into extra trips has been questioned by Fleischer (1962) and Thomas (1983). Their empirical investigations suggest that there is an inflexibility in vehicle operations relating to the constraints of drivers' hours and the scheduling of work which will prevent travel time savings from being fully used, particularly in the short-term.

It may be thought that the more inflexibility there is in vehicle operations (resulting from the constraints of drivers' hours regulations and acceptable loading and unloading times) then the greater the probability that time savings will not be fully used following road investment. To test this a computer based simulation model was built.

Using different input assumptions the results of the model suggested that while additional constraints on vehicle operations could be expected to reduce the average level of efficiency (in terms of reduced working hours) there were no "a priori" grounds to suggest that they would reduce, at the margin, the probability of using time savings. Comparing different spectrums of journey times the model provided as many cases where total idle time fell (i.e. time savings were more than fully used) as cases where total idle time rose (i.e. time savings were not fully used) following a reduction in journey times. The exact outcome was shown to be dependent upon the particular trip length distribution and the set of constraints assumed in the model.

There are several ways of trying to estimate how time savings may be used following road investment. One approach is to ask operators to guess what their response would be given the predicted reduction in journey times.

Another approach is to look at changes in utilisation before and after an investment has been made. Without a total survey of all operators using the route it is not known whether other operators are able make use of the time savings. Likewise it is possible that in other situations with only one major route impressive productivity gains could occur with only very small time savings.

Thomas carried out an historical 'before and after' analysis as well as cross-sectional analysis to determine how vehicle productivity might change following road investment in Malaysia. For the historical analysis, data was collected on vehicle productivity before and after the new Kuala Lumpur - Karak highway was opened which reduced vehicle trip times by an average of 45 minutes. Although data on the operations of various types of commercial vehicles were collected, no dramatic improvements in vehicle productivity were found following the opening of the new road section. In fact for certain vehicle types the level of trip making per day fell in the Kuala Lumpur area.

In the Malaysian cross-sectional analysis a number of elasticities were derived for different categories of commercial vehicles between trips made per day and average travel time per trip. Most of the data was collected from a roadside interview survey in which drivers were asked what trips had been made in the previous 24 hours. The elasticities found ranged from -0.2 to -0.6, so that if travel time were reduced by one per cent then trip making could have been expected to rise by between 0.2 and 0.6 per cent.

This analysis suggests that the models which predict a one per cent increase in distance travelled for one per cent decline in travel time (assuming trip distances remain constant) will clearly overestimate the effects of journey time savings. However, to estimate fully the extent to which vehicle working time savings are used it is also necessary to include loading and unloading time within trip times in the calculation of the elasticities.

It is against this background that it was decided to develop further the cross-sectional elasticity analysis using vehicle activity data from Pakistan.

3. THE ROAD FREIGHT TRANSPORT INDUSTRY IN PAKISTAN

It has been estimated that currently in Pakistan there are in the order of 45,000 trucks in operation, of which about 95 per cent are private owned. General information on private road freight transport was collected from a roadside interview survey of 3500 truck drivers. Three quarters of the trucks surveyed were two-axle Bedford trucks, 14 per cent were two-axle Japanese trucks and the remainder were divided between three-axle rigid vehicles and tractor-trailer combinations.

Less than one per cent of the trucks surveyed were owned by a company for its 'own account' operations. The industry appeared to be entirely organised on a 'hire and reward' basis. Most trucks were found to operate on the basis of picking up business where they could and going from job to job as demand required. It was very common for drivers to work away from base for up to three weeks. It was found that on average drivers of Bedford trucks returned to base after 7 days and returned to their family after 17 days.

The driver is responsible for finding the load, for collecting revenue, and for repairing the truck. When he returns to base he has to account for the revenue earned and the expenditures incurred. About 80 per cent of drivers are employees and approximately 17 per cent own their vehicle. The remainder own a part share of the vehicle.

There is an extensive network of freight agents who assist the driver to find a load. In the survey it was found that over 60 per cent of loads were obtained using agents. In practice vehicles could usually be found for a consignor within one hour.

4. SURVEY PROCEDURE

A 'Vehicle Activity Survey' was undertaken whereby different activities were recorded and timed as they occurred on a continuous basis for periods lasting from five days to over four weeks. The data was collected by both survey staff and by cooperative drivers. The survey staff travelled with their allotted trucks continuously throughout the period, if necessary sleeping on board the truck as it travelled. In total over 600 days of useful data were collected, about one fifth of this being recorded by drivers, the rest by survey staff. This comprised 24 periods of data related to conventional two-axle Bedford trucks, seven periods to Bedford tanker trucks and 14 periods to conventional two and three-axle Mercedes trucks.

Detailed records of the timing of all movements, rest periods, loadings, unloadings, waiting periods, and repairs were collected. Vehicle stops of less than 15 minutes were ignored. Additional data on the distance travelled, costs incurred and revenue earned were also recorded.

5. THE PATTERN OF VEHICLE USE

The Vehicle Activity Survey collected data on trucks engaged on a variety of patterns of operation and covered a wide spectrum of trip lengths. The 45 survey periods covered 405 loaded trips and 327 empty trips. The mean distances recorded for loaded and empty trips were 347 km and 150 km respectively.

To analyse the pattern of vehicle productivity and time use it was necessary, as far as possible, to allocate time spent in different activities into empty and loaded trip periods. For each trip the time spent moving, loading, unloading, resting, or under repair was totalled. It was found that on average each loaded trip and each empty trip was composed of approximately 5 and 3 separate movements (broken by rest periods) respectively.

A loaded trip was defined to begin with the start of loading of an empty truck. A loaded trip was defined to end at the time it was completely unloaded; so a sequence of multiple partial loadings or unloadings were all to be counted as part of one loaded trip. A series of empty movements (made in any direction) were counted as part of one empty trip. No difference was distinguished between resting and waiting in the analysis.

TABLE 1. MEAN TIMES SPENT ON EACH ACTIVITY FOR LOADED AND EMPTY TRIP PERIODS

	Moving Hrs	Loading Hrs	Unloading Hrs	Resting Hrs	Repair Hrs	Total Hrs
Loaded Trips	10.8	2.2	1.9	6.5	0.3	21.8
Empty Trips	4.4	—	—	11.3	0.9	16.5
Empty Periods Between Loaded Trips	—	—	—	7.1	0.6	7.7

Table 1 gives the distribution of time per trip spent in different activities. In total, trucks were found to be loaded 56 per cent of the time. Rest and waiting time accounted for 30 per cent of loaded trip time, but overall 63 per cent of rest and waiting occurred while the truck was empty.

The average duration between the end of loading and arrival at the destination was found to be 14.9 hrs which gives an average loaded journey speed (including intermediate rest periods) of 23 kph. From the data an estimate of 109,000 km was calculated for annual vehicle travel. Both of these estimates were very close to estimates derived from other surveys which were also carried out as part of the study.

A high degree of time utilisation was found for the survey vehicles. Most vehicles worked round the clock with activity interrupted only by short rest and waiting periods. Vehicles were found to be moving 40 per cent of the time and loading or unloading a further 11 per cent of the time. Rest periods accounted for 46 per cent of the time.

Fig. 1 shows how vehicle use changed throughout the day. The most active movement times were found to be between 16.00 hrs and 02.00 hrs. Even at the quietest time of day, 06.00 hrs, 37 per cent of vehicles were working. The most active loading and unloading times were in the middle of the working day between 08.00 hrs and 18.00 hrs.

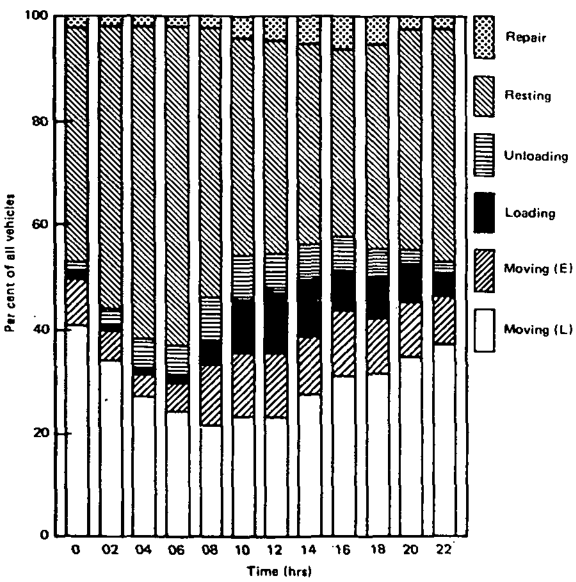

Fig. 1. Distribution of activities by time of day

6. THE RELATIONSHIP BETWEEN TRIP FREQUENCY AND TRIP TIME

In order to estimate the extent to which journey time savings could be translated into extra trip making a series of elasticities were derived from the Vehicle Activity Survey data relating trip frequency to trip time. The survey data was collected over periods lasting up to four weeks. During the survey, some of the truck drivers took their normal 'day off' for recreational rest while other drivers did not. In order to estimate the extent to which this lack of uniformity may have biased the results an additional data set (referred to as the 'adjusted data set') was prepared which smoothed the time spent on long rest periods. It was also decided to prepare another data set which excluded data from the tanker trucks which have their own unique pattern of operation. The following three data sets were prepared:

(i) The basic data set (45 cases)
(ii) The adjusted data set (45 cases)
(iii) The adjusted data set excluding tankers (38 cases)

Each data set was derived from the 45 survey periods of the Vehicle Activity Survey. For each case mean values of number of the trips made per day, and the moving and working times per trip were calculated.

It is mentioned above that the Malaysian study calculated elasticities between trips made per day and movement time per trip; the analysis is useful for indicating how trip frequency (and hence total distance travelled) might change for each vehicle with a change in travel time.

An elasticity of -1 between trips made and movement time is unlikely where loading and unloading times are significant. An elasticity of this magnitude would imply that total working time (including moving loading, and unloading time) will increase with travel time savings.

The most convenient way of estimating an elasticity is by using a log-log regression analysis. The elasticity is the coefficient 'b' in the following regression:

Log (trip frequency) = a + b * Log (trip time)

Table 2 gives the results of regressions relating trips per day to mean trip movement times for the three data sets mentioned above. Separate regression results are given for 'loaded trips' and for 'all trips'. 'All trips per day' refers to the mean number of loaded and empty trips made per day.

TABLE 2. REGRESSIONS RELATING TRIPS PER DAY TO MOVING TIME PER TRIP

Basic data set N = 45

(1) Log (all trips per day) = 0.682 - 0.698 * Log (movement time per trip)
(se = 0.036)
R squared value = 0.90. T value = -19.6

(2) Log (loaded trips per day) = 0.518 - 0.709 * Log (loaded movement time per trip)
(se = 0.046)
R squared value = 0.85. T value = -18.1

Adjusted data set N = 45

(3) Log (all trips per day) = 0.715 - 0.755 * Log (movement time per trip)
(se = 0.032)
R squared value = 0.93. T value = -23.7

(4) Log (loaded trips per day) = 0.56 - 0.768 * Log (loaded movement time per trip)
(se = 0.042)
R squared value = 0.88. T value = -18.0

Adjusted data set excluding tankers. N = 38

(5) Log (all trips per day) = 0.724 - 0.765 * Log (movement time per trip)
(se = 0.043)
R squared value = 0.90. T value = - 17.9

(6) Log (loaded trips per day) = 0.506 - 0.702 * Log (loaded movement time per trip)
(se = 0.048)
R squared value = 0.86. T value = - 14.6

The regressions shown in Table 2 have high R squared values and are very significant. The derived elasticities relating trips per day to mean movement time per trip lie within the range -0.70 to -0.77, so that if mean movement times are cut by one per cent then trip making will rise by just over 0.7 of one per cent. These elasticities are much higher than those found in the Malaysian study.

To estimate the extent to which time savings can be fully used following road investment it is necessary to calculate the elasticities using total working time including loading and unloading time. It is only in this case that the elasticity coefficients provide an unbiased estimate of the proportion of time savings which will be translated into extra trips. Regressions showing these elasticities are given in Table 3.

TABLE 3. REGRESSIONS RELATING TRIPS PER DAY TO WORKING TIME PER TRIP

Basic data set N = 45

(7) Log (all trips per day) = 0.909 - 0.838 * Log (mean total working time per trip)
(se = 0.047)
R squared value = 0.88. T value = -17.7

(8) Log (loaded trips per day) = 0.873-0.913* Log (mean loaded work time per loaded trip)
(se = 0.061)
R squared value = 0.84. T value = -14.9

(9) Log (loaded trips per day) = 0.90 - 0.864 * Log (mean total time per loaded trip)
(se = 0.045)
R squared value = 0.90. T value = -19.3.

Adjusted Data Set N = 45

(10) Log (all trips per day) = 0.968 - 0.913 * Log (mean total working time per trip)
(se = 0.041)
R squared value = 0.92. T value = -22.4

(11) Log (loaded trips per day) = 0.951 - 0.995 * Log (mean loaded work time per loaded trip)
(se = 0.054)
R squared value = 0.89. T value = - 18.4

(12) Log (loaded trips per day) = 0.969 - 0.932 * Log (mean total work time per loaded trip)
(se = 0.038)
R squared value = 0.93. T value = -24.4

Adjusted data set excluding tankers. N = 38

(13) Log (all trips per day) = 1.00 - 0.95 * Log (mean total working time per trip)
(se = 0.054)
R squared value = 0.89. T value = -17.5

(14) Log (loaded trips per day) = 0.88 - 0.925 * Log (mean loaded work time per loaded trip)
(se = 0.066
R squared value = 0.85. T value = 14.1

(15) Log (loaded trips per day) = 1.03 - 0.98 * Log (mean total work time per loaded trip)
(se = 0.052)
R squared value = 0.91. T value = 18.7

In Table 3 for each data set three elasticities are presented which relate the following variables:

(i) 'all trips per day' to 'mean total working time per trip'
(ii) 'loaded trips per day' to 'mean loaded working time per loaded trip'
(iii) 'loaded trips per day' to 'mean total working time per loaded trip'

The last type of elasticity provides an estimate (as far as is practical in Pakistan conditions) of the response of 'round trip' making to total working time per round trip. In the analysis total working time refers to all empty and loaded moving time and loading and unloading time. Loaded working time refers to loaded moving time and loading and unloading time. No rest, waiting, or repair time is included in the calculation of working time.

All of the regressions shown in Table 3 are highly significant and have high R squared values. The elasticities range from -0.84 to -1. Fig. 2 gives a typical plot of the Log-Log relationship (in this case the data used in Regression 12 is used). Overall, by introducing loading and unloading into the analysis, the elasticity values have risen by 25 per cent. The mean value of the elasticities is -0.92, so that, following road investment, commercial vehicles could be expected to devote over 90 per cent of their resulting time savings to extra trip making. The analysis suggests that the proportions of working time and idle time would hardly change with a reduction in journey times. Hence, in the calculation of commercial vehicle operating costs for Pakistan, it is reasonable to assume that time savings would be fully used and that working time per year remaining constant.

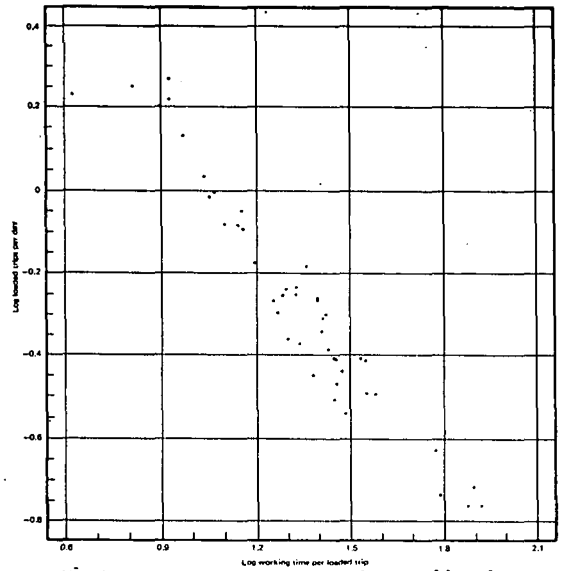

Fig. 2. Loaded trips per day against working time per trip

7. CONCLUSIONS

Vehicle time utilisation has been relatively neglected as an area of research and yet it plays an important part in the calculation of benefits arising from journey time savings. To estimate satisfactorily the benefits of time savings following a road investment it is necessary to predict the likely change in vehicle utilisation. However, there has been disagreement amongst various Authors on the extent to which time savings can be translated into extra trips. Some studies have suggested that a large part of time savings cannot be used readily.

A vehicle utilisation survey in Pakistan found that freight vehicles were used very intensively. It was found that vehicle running accounted for 40 per cent of the time and that with loading and unloading vehicles were in active use for over 12 hours per day.

From the survey data it was possible to derive a series of elasticities relating trip frequency to mean trip working time. The results ranged from -0.84 to -1 with a mean value of -0.92. The analysis suggests that following road investment in Pakistan over 90 per cent of journey time savings of commercial vehicles are likely to be translated into extra trips.

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