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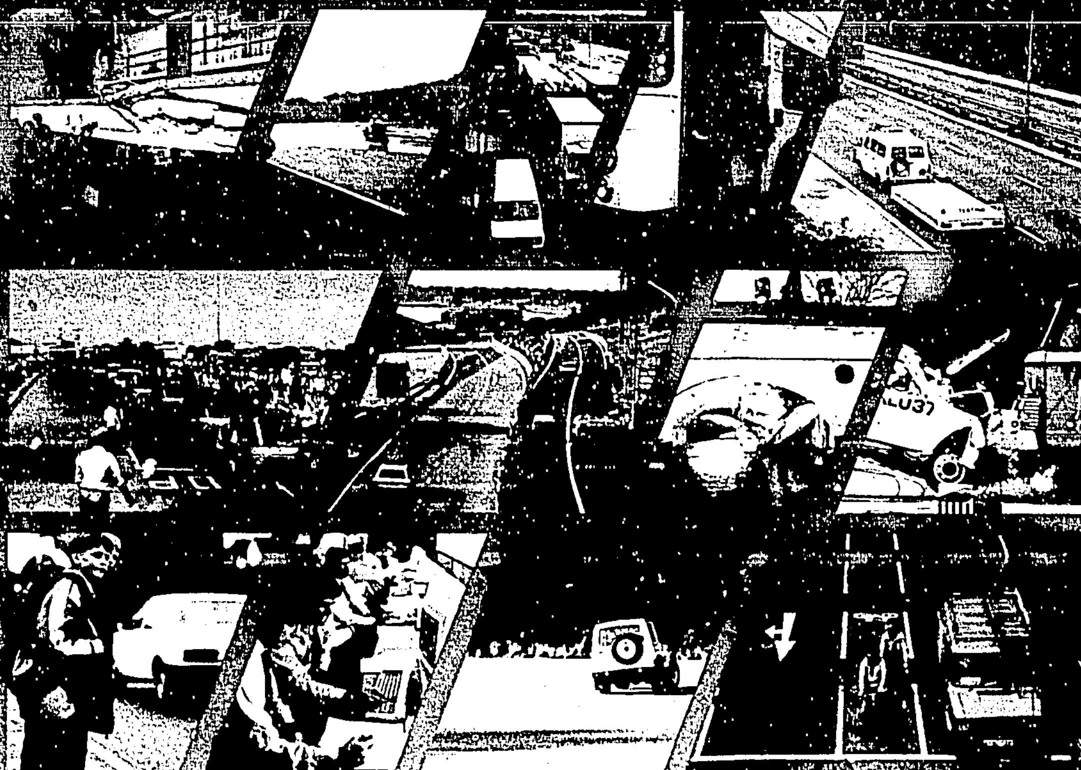

Pakistan Road Freight Industry: An analysis of tariffs, revenues and costs

by J L Hine and A S Chilver

An executive agency of THE DEPARTMENT OF TRANSPORT

Project Report 94
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PROJECT REPORT 94

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By J L Hine and A S Chilver

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EXECUTIVE SUMMARY

The research described in this report is part of a major study carried out by the Overseas Unit of the Transport Research Laboratory in cooperation with the National Transport Research Centre of Pakistan in Islamabad. From 1985 to 1987 a wide range of data was collected on Pakistan's private road freight transport industry including information on freight tariffs, vehicle utilisation, operating costs, vehicle ownership and management, and road roughness. A general description of the industry has been presented in Research Report 314 and an analysis of vehicle time utilisation in Research Report 333. This report describes an analysis of tariffs, revenues and costs.

There is a need to improve the understanding and modelling of the factors which determine freight costs and tariffs for a wide range of planning purposes. Although a number of major studies of vehicle operating costs have been carried out it has been found that the cost relationships can vary considerably between countries and hence there is often a need to adjust the models to suit local conditions. Despite the importance of freight tariffs in influencing the nature and location of economic activity and in determining the choice of mode and vehicle type relatively little analysis of freight tariffs has been carried out.

It is sometimes claimed that tariffs are unreliable and difficult to derive, but this was not found to be the case in Pakistan. Good quality, consistent data was readily obtained. These showed that from 1982 to 1986 tariffs rose closely in line with inflation. The effects of flow imbalances and seasonal variations could be easily seen. There is a net outflow of goods by road from Karachi and as a result tariffs per kilometre were about one third higher for vehicles travelling away from Karachi than in the opposite direction. A small but distinct seasonal pattern in tariffs was found. For journeys away from Karachi tariffs were above the mean by about 0.75 per cent for the first half of the year and they were below the mean by about 1 per cent during the latter half. The pattern of tariffs for journeys in the opposite direction followed an almost mirror image of this with lower tariffs in the first half and higher tariffs in the latter half of the year.

The effects of distance, time, travel direction, load weight, road roughness and vehicle type on tariffs were investigated through the use of regression techniques. It was found that tariffs were much more dependent on journey distance than on journey time. Small and moderate changes in road roughness had no significant effect. The following log-log multiple regression was estimated for the main paved road network, ($N = 1388$, $R^2 = 0.86$):

$$
\begin{aligned}
\text{Ln Tariff} = {} & 1.74 \\
& + 0.24 \text{ Direction Variable (to Karachi=0, from Karachi=1)} \\
& + 0.447 \text{ Ln Distance (km)} \\
& + 0.198 \text{ Ln Time (hrs)} \\
& + 0.282 \text{ Ln Load Weight (tonnes)} \\
& + 0.317 \text{ Ln New Vehicle Value (1000s Rs)}
\end{aligned}
$$

To examine the effect of large differences in road roughness on revenues a comparison was made between a very rough route in the Mekran area of Baluchistan (roughness: 13,000 mm/km on the BI scale) and routes on the rest of the main road network (roughness: 4,800 mm/km on BI scale). On the rough route, revenues per vehicle kilometre were estimated to be between 10 per cent and 24 per cent higher depending on vehicle type. However because of the lower loads carried on the rough route, revenues per tonne km were between 63 per cent and 79 per cent higher on this route compared with the main road network.

Observed revenue and cost data were compared with estimates derived from the three standard models of vehicle operating costs (VOCs) used for road appraisal in developing countries. Measured on a cost per kilometre basis, and excluding fuel consumption, both the Transport Research Laboratory's Road Transport Investment model (RTIM), derived from data from Kenyan and the Caribbean, and the World Bank's Highway Design and Maintenance Standards Model (HDM), using Brazilian derived VOC relationships, were found to substantially overestimate the costs and revenues of trucks operating in Pakistan. The HDM VOC model incorporating Indian derived relationships, was found to give fairly close results for smooth roads; however in common with the other models, it also appeared to overestimate costs and tariffs for very rough roads. Hence there were good grounds to believe that all three models would overestimate the reductions in the per kilometre vehicle operating costs from improving unsurfaced roads in Pakistan. However corrections would also be needed to take account of the greater loads carried by vehicles on smooth roads.

At the time of the surveys two-axle Bedford trucks with a seven tonne design capacity made up three quarters of the truck fleet, the remainder were mostly two and three-axle Japanese trucks. The analysis showed that for long distance trips the Bedford trucks were unprofitable. This was not the case for the Japanese trucks which have a larger carrying capacity. Repair costs increased, and annual travel decreased with vehicle age, but age accounted for only a relatively small proportion of the variation found in these items. It was estimated that after ten years, annual travel declined by 42 per cent for the two-axle Japanese trucks but by only 13 per cent for the Bedfords.

PAKISTAN ROAD FREIGHT INDUSTRY: AN ANALYSIS OF TARIFFS, REVENUES AND COSTS

ABSTRACT

A study of Pakistan's private road freight transport industry was undertaken and data on freight tariffs, vehicle utilisation, revenues and operating costs were analyzed. Over a period of four years it was found that average tariff levels closely followed the rate of inflation with a small marked seasonal variation depending on trip direction. Using multiple regression analysis of cross-sectional data, tariffs were shown to be a function of trip distance, trip time, direction, vehicle type and load weight. Only in the comparison of extreme conditions was roughness found to provide some additional explanation of freight tariffs. Observed revenues and costs were compared with predictions of vehicle operating costs given by the World Bank's Highway Design and Maintenance Standards Model (HDM) and by the Transport Research Laboratory's Road Transport Investment Model (RTIM). It was found that, in Pakistan's conditions, the models would over-estimate the reduction in the per-kilometre vehicle operating costs from improving the road network. However allowances would also have to be made to take account of the greater loads carried on smooth roads. An analysis of trends with vehicle age indicated that annual travel fell with increasing vehicle age while maintenance costs rose. An examination of vehicle profitability showed that two-axle Bedford trucks (with 7 tonne load design capacity) were likely to be far more profitable on short distance routes (below 700 kms) while trucks with larger capacity were likely to be more profitable on longer distance routes. The report supplements TRRL Research Reports 314 and 333.

1. INTRODUCTION

This Report forms part of a study of Pakistan's freight transport industry that was carried out by the Overseas Unit of the Transport and Road Research Laboratory in cooperation with the National Transport Research Centre of Pakistan in Islamabad. The overall aims of the study were to investigate the operation, performance, costs, tariffs and management of the industry. The relevant information was collected during 1985 and 1986 by formal surveys and a number of informal interviews and meetings. A general description of the industry is provided in Research Report 314 and an analysis of vehicle time utilisation is provided in Research Report 333.

This Report addresses three separate, but interrelated, issues of national transport planning. These are:-

a) Freight tariffs play a key role in influencing the nature and location of economic activity and they are critically important in both the choice of mode and the choice of vehicle used to transport freight. For planning purposes it is important to be able predict freight tariffs as accurately as possible and for this reason it is useful to try to model freight tariffs directly. Information on vehicle operating costs can certainly assist with this task but it is often unavailable and additional information on profitability, load factors, and empty running is also required.

b) In order to assess the efficiency and long term viability of the different components of Pakistan's road freight transport industry it is important to be able to quantify total revenues and operating costs and hence identify the overall profitability of the industry and how the composition of the industry may change over time.

c) There is a need to improve our modelling of vehicle operating costs (VOCs) for road investment planning. Standard models of vehicle operating costs have been developed for the appraisal of road investment in developing countries. However, in practice, it has been found that there are a number of problems associated with the use of these models. The form of the relationships between the relevant physical and economic parameters and VOCs varies between countries, and the models often need to be adjusted to suit local conditions. An analysis of revenues and tariffs can assist with modelling the most appropriate relationships.

2. DATA SOURCES

The Report draws on the following sources of information :-

i) The Roadside Interview Survey

This was the main data collection exercise of the whole study. In total 3500 truck drivers were interviewed at 39 sites throughout Pakistan during the period from January to April 1986. Drivers were asked to provide details of their current journey and their previous empty journey (i.e. origin, destination, journey distance, journey time, load, and tariff). In addition they were asked to estimate their consumption of fuel, tyres and their expenditure on repairs and the average distance travelled. Other information gathered included data on vehicle age, make, type, value, ownership, fleet management, finance, total revenue, accidents and insurance.

In the survey, two-axle Bedford trucks accounted for 76 per cent of all vehicles surveyed, while two-axle Japanese trucks (predominantly Hino, Isuzu and Nissan vehicles) accounted for a further 14 per cent of vehicles. Technical details of the different vehicles surveyed are included in Table A1 of the Appendix, further details are given in TRL Research Report 314.

ii) Truck Drivers' Cost and Revenue Diaries

Many drivers were found to keep detailed records of their costs and revenues. In total, Diaries of over 50 different trucks were collected covering about 600 vehicle months. The data collected relates to different periods from 1974 to 1986. The data were aggregated into monthly periods before being analyzed and to be consistent with the other surveys adjustments were made for inflation; all Diary data are expressed at 1986 prices.

iii) Vehicle Activity Survey

In this survey, data was collected by cooperative drivers and survey staff specifically recruited to travel with the vehicles' crew. A continuous record of each vehicle's activities and the costs and revenues incurred were recorded over periods lasting from one to four weeks. In total, 47 periods of data were collected. Data was collected from July 1985 to September 1986.

iv) Past Tariff Data

In order to identify trends and seasonality in tariffs, past tariff data were collected from records of freight agents. In total 123 different sets of tariffs were collected, each relating to a particular journey, cargo and vehicle type.

v) Road Roughness Data

In order to assist with the analysis of cost and tariff data, information on road roughness was required. To supplement data already collected for most of the main roads, an additional survey of road roughness was undertaken for the study. This survey primarily covered the rough unsurfaced roads of Baluchistan and the more important interior roads of the Punjab. Data was collected on 70 road links covering a distance of over 5700 km. In the survey, roughness levels were measured with a bump integrator unit attached to the back axle of a survey vehicle and the data was then calibrated with a 'MERLIN', TRRL's low cost roughness measuring instrument (Cundill, 1991). In total, the two sources provided data on road roughness for 176 links covering 14,000 km. All roughness data in the Report are presented in BI units (i.e. in mm/km).

3. TARIFF TRENDS AND SEASONALITY

Before tariffs can be used as a basis for general transport planning purposes it is useful to know how stable they are over the long term, and to what extent they might fluctuate from season to season. These issues are addressed in this Section.

3.1 THE DATA

Past tariff data was collected from freight agents located in five major centres of Pakistan. The data consisted of past records of the tariff levied by the freight agents for a particular journey, with a particular commodity carried by a particular vehicle type. The tariff data were recorded twice each month mostly covering the period from 1982 to 1986.

In all, 123 different tariff sets were collected. Of these, 56 were collected from agents in Karachi, 29 from Lahore, 24 from Abbottabad, 11 from Quetta and three from Rawalpindi. The vehicle types included two-axle Bedford trucks, two-axle Isuzus and Hinos, and tractor trailers manufactured by Nissan and Mercedes.

In order to identify seasonal patterns, any tariff sets which were fixed for a period of six months (12 periods) or more were excluded from all analyses. This left a basic data set of 86 different tariff sets which ran from the beginning of January in 1982 to the end of June 1986, a total of 108 periods.

Time series analysis was used to establish what patterns if any were present in the data. Simple regression lines of tariffs against time were also plotted through the data sets in an attempt to identify past trends and seasonality.

3.2 GENERAL TARIFF TRENDS

A regression line was fitted through the data, and from this it was found that there was a nominal increase in tariff levels of approximately 33 per cent from the period January 1982 to June 1986. This represents a real increase of between zero and one per cent as the consumer price index rose by 32 per cent over the same period. Tyre prices also rose by 28 per cent in nominal terms, fuel prices rose by 29 per cent and the price of a Bedford chassis rose by 18 percent. A clearly distinguishable seasonal pattern was also found in the data with a broad seasonal deviation from the annual mean of approximately plus one per cent in the first half of the year to -1.5 per cent in the latter half of the year.

3.3 TARIFF TRENDS BY DIRECTION

Tariff rates per kilometre, are markedly higher, throughout Pakistan, for vehicles travelling away from Karachi than in the opposite direction. This difference reflects the higher flows of freight travelling inland from Karachi. In order to analyse the differences in tariff trends the data set was split by direction of travel; 73 tariff sets related to journeys made in the 'from Karachi' direction and 13 were in the opposite direction, 'to Karachi'. Mean tariffs did not increase significantly in real terms for trips in either direction.

For the data set, average tariffs for trips in the 'from Karachi' direction were over three times the value of tariffs 'to Karachi'. This difference predominantly reflects differences in trip length and vehicle type within the data set, rather than the underlying variation in tariff rates due to traffic direction. Figure 1 illustrates the trend of mean tariffs 'from Karachi' over the four and a half year period and points towards a seasonal pattern. The seasonality is more clearly illustrated in Figure 2 where the mean residuals of the best fit line for the 'from Karachi' data have been plotted. This shows a pattern of deviation of

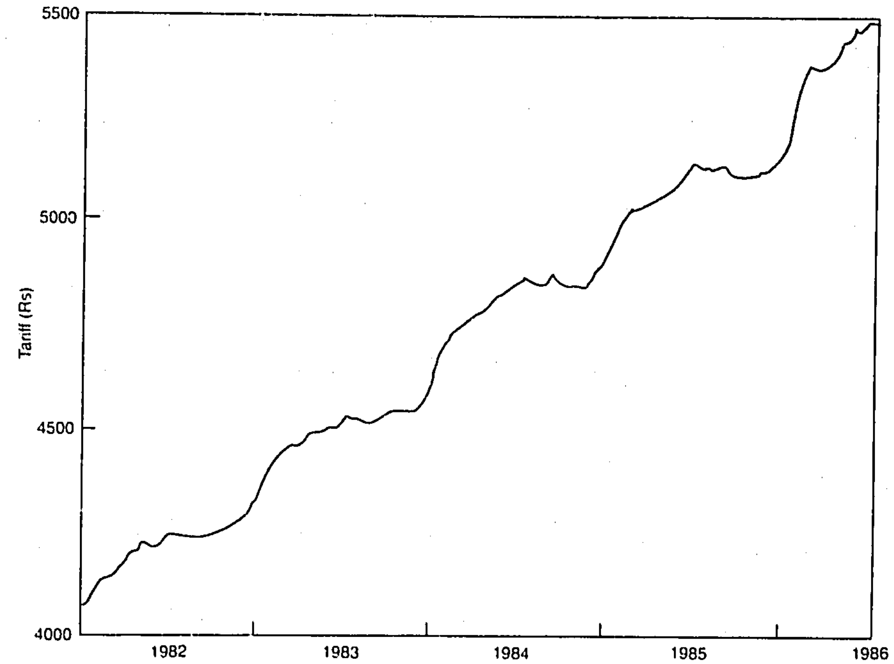

Fig. 1 Tariff trends – from Karachi, January 1982 to June 1986

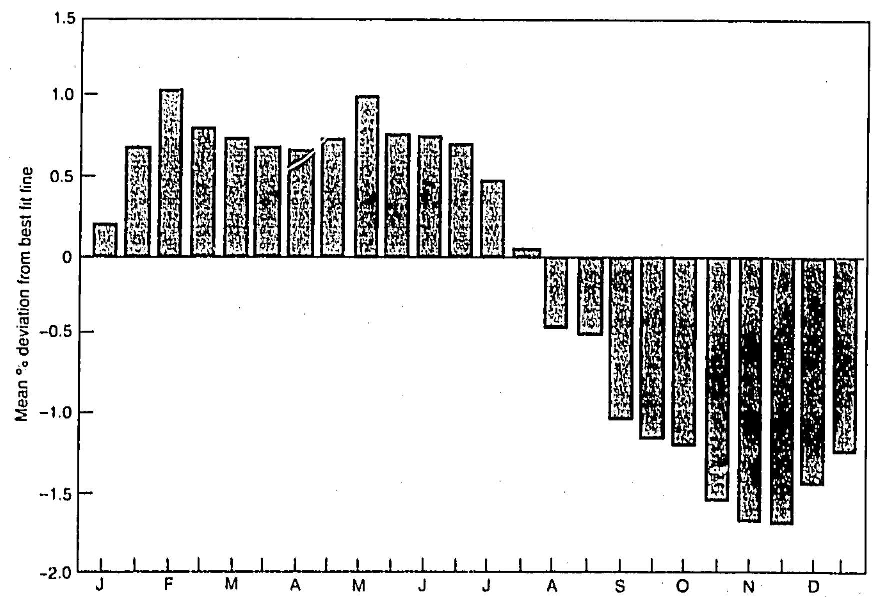

Fig. 2 Tariff seasonality – from Karachi, January to December

up to +1.1 per cent in the first half of the year and down to -1.7 per cent in the second half.

Figure 3 shows the trend for mean tariffs 'to Karachi' and indicates a strikingly different pattern of seasonality. When the mean of the residuals of the best fit line for the 'to Karachi' data is plotted (Figure 4), the seasonal pattern appears almost to be a mirror image of the pattern 'from Karachi'. Tariffs are relatively low during the first half of the year, between 3.3 and 0.1 percent below the best fit line, and 0.4 to 2.2 per cent above the line during the last five months of the year.

It is thought that the seasonal patterns observed above reflect in part the agricultural cycle in Pakistan and the movement of agricultural commodities as well as the seasonal patterns of imports. During the latter part of the year, large quantities of rice are moved from the growing areas of Punjab and Sind to the port of Karachi. Between 1982 and 1984, approximately 85 per cent of all rice for export was shipped 'to Karachi' between the months of October and January (Majeed, 1985). A similar pattern can be observed for the movements of cotton 'to Karachi' for export (Japan International Cooperation Agency, 1983). This is likely to increase demand for freight transport in this direction and therefore inflate tariff rates during this period as shown in Figure 4.

Conversely, national statistics on commodities imported into Pakistan between 1983 and 1985 (i.e. goods moving in the 'from Karachi' direction) indicate that imports are relatively higher during January to June and lower during July to December (Federal Bureau of Statistics, 1986). This would tend to increase tariffs in the 'from Karachi' direction during January to June; it would also tend to reduce tariffs in the opposite direction during this time as there would be relatively fewer return loads available in the 'to Karachi' direction for the increased number of trucks trying to return. This pattern would appear to be in sympathy with the seasonality illustrated in Figures 2 and 4.

4. A CROSS-SECTIONAL ANALYSIS OF TARIFFS AND OTHER DATA

In the previous section freight tariffs were analyzed from a historical perspective to identify trends and seasonal differences. In contrast in this section a cross-sectional regression analysis of a range of data (trip distance, time, direction, load weight, vehicle type and roughness) is undertaken to explain freight tariffs. Because the data were collected over a comparatively limited period (i.e. four months) the influence of time trends was not addressed in this part of the analysis.

4.1 THE DATA

The main data sources for this analysis were the Roadside Interview Survey and the Road Roughness Surveys. In order to investigate the relationships between tariffs and road roughness, it was necessary to derive average road roughness values for each vehicle trip. This was computed by averaging the roughness values of all the links in the trip, based on the assumption that truck drivers chose the minimum distance path between their origin and destination.

A variety of truck configuration and body types are utilised in Pakistan's road freight industry. As these each have different operating characteristics which affect the tariff they levy, they were separated out into four groups (see Table 1). Freight rates for commodities transported by tanker (such as oil and petrol) are usually fixed, and so all tankers were excluded from the analysis. Vehicles carrying loads of less than one ton were also excluded. As before the data sets were split by direction of travel.

Analysis of the data indicated that for journeys made on the unpaved network of roads in the Mekran desert area of Baluchistan a high road roughness level was found to be associated with high tariffs, a marked imbalance in traffic flow direction and a high degree of empty running. To provide a better explanation of the relationships that govern freight tariffs on the major part of the paved road network the Mekran data were mostly excluded from the analysis in this section. A more comprehensive analysis of the Mekran data, incorporating the effect of more extreme road roughness levels, is made in the comparison of rough and smooth routes in Section 5.

In this Section the term 'tariff' relates to the actual sum of money paid for a particular loaded trip. Hence 'tariff per kilometre' relates to the tariff paid divided by the loaded distance travelled. Empty travel is not explicitly analyzed in the Section.

4.2 THE EXPLANATION OF TARIFFS

A variety of regression models were used to analyse the data in order to provide the best explanation of freight tariffs. The best overall explanation of freight tariffs was given by the log-log multiple regression shown in Table 2. This is highly significant with a high R^2 value. In the regression, tariffs are shown to be statistically related to direction, (represented by a "dummy variable"), distance, time, load weight and vehicle type (represented by new vehicle value). The term relating to direction ($e^{0.24 \cdot D}$) indicates that traffic travelling from Karachi will be 27 per cent higher than that travelling in the opposite direction. The coefficients for the last four variables are equivalent to elasticities between the variable and the freight tariff. Hence, for example, a one per cent increase in load weight will increase tariffs by 0.28 per cent.

In the form of the regression model used here the derived regression line passes through the origin. To test whether there was an 'irreducible minimum' component of the tariff to account for the inescapable costs of undertaking and organizing the trip a variety of constant sums of money, representing this component, were subtracted from the tariff to see whether the explanation of the regression model could be improved. In the event, it was found that no improvement could be made to the explanation of the basic model.

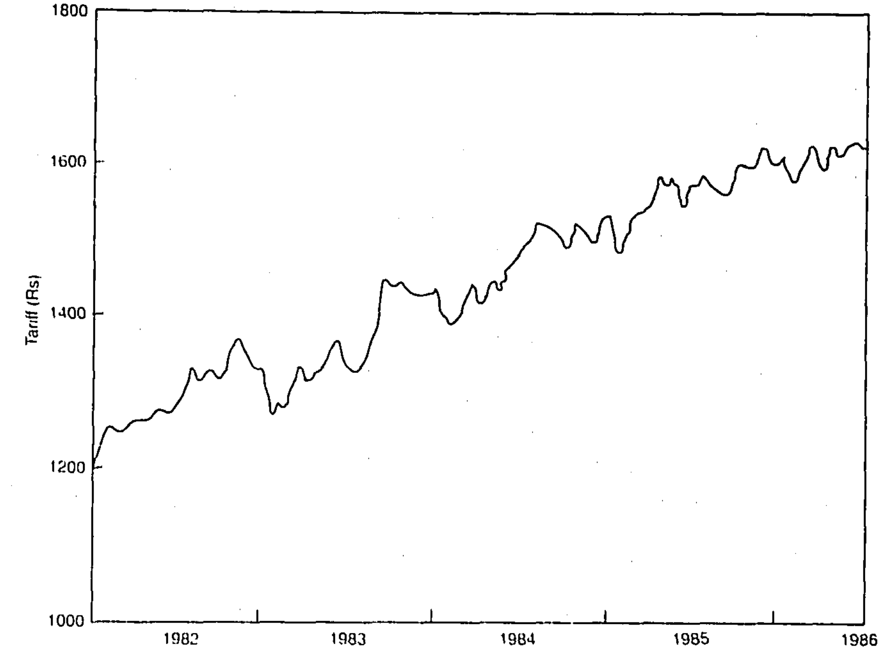

Fig. 3 Tariff trends - to Karachi, January 1982 to June 1986

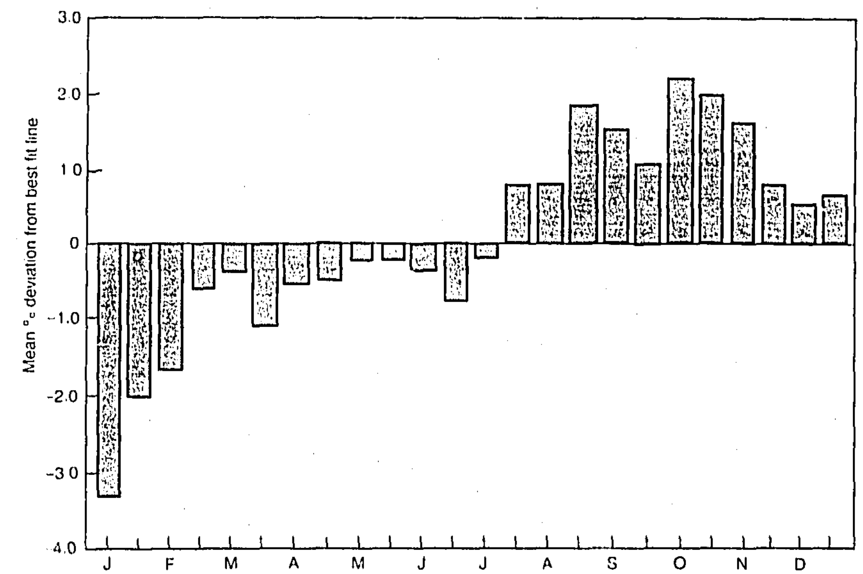

Fig. 4 Tariff seasonality - to Karachi, January to December

TABLE 1

Mean values for the data sets (1986 prices, excluding Mekran data)

	Two-Axle Bedfords		Two-Axle Japanese	
	To Karachi N = 494	From Karachi N = 536	To Karachi N = 88	From Karachi N = 109
Distance (kms)	665	616	925	859
Trip time (hrs)	28.1	26.8	46.6	40.0
Cargo weight (tonnes)	7.9	8.3	12.3	12.6
Roughness (mm/km)	4903	5158	5802	5415
Tariff (Rs)	1626	2153	3476	3956
Tariff per km. (Rs)	3.69	4.23	4.28	4.81
Tariff per tkm.(Rs)	0.59	0.63	0.37	0.46
New vehicle value (Rs)	155000	155000	337000	337000
	Three-Axle trucks		**Tractor Trailers**	
	To Karachi N = 35	From Karachi N = 46	To Karachi N = 43	From Karachi N = 37
Distance (kms)	965	1028	932	880
Trip time (hrs)	49.3	57.9	52.5	58.5
Cargo weight (tonnes)	18.5	24.2	24.0	31.5
Roughness (mm/km)	4497	4929	[illegible]355	4849
Tariff (Rs)	3931	7113	4[illegible]17	8357
Tariff per km. (Rs)	4.63	7.06	4.74	10.09
Tariff per tkm.(Rs)	0.26	0.30	0.21	0.35
New vehicle value (Rs)	483000	483000	534000	534000

Source: Roadside Interview Survey

TABLE 2

The prediction of freight tariffs using a variety of variables
(Excluding Mekran data)

		St. error
Ln Tariff =	1.7365	
	+ 0.24 Direction Variable (to Karachi=0, from Karachi =1)	0.0191
	+ 0.4468 Ln Distance (km)	0.0264
	+ 0.1976 Ln Time (hrs)	0.0233
	+ 0.2822 Ln Load Weight (tonnes)	0.0218
	+ 0.3167 Ln New Vehicle Value (1000 Rs)	0.0287

(Road Roughness not significant)

N = 1388 R^2 = 0.839 t value = 37.9

As expected, the analysis found that journey time and distance were highly correlated. Despite this, the elasticity between tariffs and journey distance was consistently found to be more than double that between tariffs and journey time (see Tables 2 and 3). The results can be compared with the analysis of the vehicle utilisation survey data given in Research Report 333. In that analysis it was suggested that journey distance could account for 55 per cent, and journey time 45 per cent, of the total influence that these two variables had on the tariffs of Bedford trucks. The differences in the results shows the difficulties in distinguishing the separate effects of time and distance because of the strong correlation between the variables.

In the analysis, an elasticity coefficient of 0.05 was found between road roughness and tariffs. However it was not statistically significant at the 5 per cent level of probability (t value: 1.16) and was omitted from the regression model. A similar regression was carried out with the Mekran data included (see Table A2 in the Appendix). In this regression road roughness was found to be significantly correlated with tariffs (t value: 5.14). However there are grounds to suggest that the elasticity coefficient (0.18) is biased because of the imbalance in traffic flows and high level of empty running in the Mekran.

In Table 3, multiple regressions for the individual vehicle types are presented. The R^2 values for these regressions, and their associated t values, are less than for the regression of the combined data shown in Table 2. As before, road roughness was not found to be statistically significant. The coefficients relating to direction are higher for the larger vehicles. In part, this may be an effect resulting from the longer trips made by these vehicles. The elasticities for load weight are higher for the intermediate sized vehicles (the two and three-axle Japanese trucks) than for the two-axle Bedford trucks and the tractor-trailers. This may reflect the wider range of loads carried by these vehicles.

4.3 THE EXPLANATION OF TARIFFS PER TKM AND PER KM

In many situations, tariffs are expressed on a per tonne kilometre (tkm) or per kilometre (km) basis. Two further sets of analyses have therefore been carried out similar to those described above. Table 4 presents two multiple regressions which explain tariffs per tkm. Because the first regression is mathematically closely related to the regression shown in Table 2 many of the coefficients are the same. As expected, because of the economies of scale, the elasticities between tariffs per tkm and distance and load weight are negative. The R^2 value and t value are less than for the overall regression explaining tariffs. In order to help provide an estimate of tariff per tkm without knowledge of the journey time or the vehicle type the second regression was included in Table 4.

Table A3 in the Appendix presents multiple regressions of tariffs per km for the four different vehicle types. These regressions are closely related to those shown in Table 3 and, as before, many of the coefficients are the same but in this case the distance coefficients are negative. The R^2 values and significance of the regressions are less than the corresponding regressions in Table 3.

TABLE 3

The prediction of freight tariffs for different vehicle types
(Excluding Mekran data)

Variable to predict Ln Tariff	Two-Axle Bedfords	Two-Axle Japanese	Three-Axle Japanese	Tractor Trailers
Constant	3.5488	2.3303	2.0328	3.3027
Direction	.2211	.1287	.3122	.6645
	(.021)	(.056)	(.066)	(.082)
Ln Distance	.4349	.5692	.6681	.4648
	(.029)	(.084)	(.062)	(.126)
Ln Time	.1984	.1604	not sig.	.2392
	(.026)	(.07)		(.092)
Ln Load Weight	.2165	.5227	.5811	.2761
	(.024)	(.083)	(.097)	(.117)
N	1030	197	81	80
R^2	.809	.786	.752	.715
t value	32.9	13.3	8.8	6.9

(Note: standard errors in brackets, all units as in Table 2)

TABLE 4

The prediction of freight tariffs per tonne km
(Excluding Mekran data)

Ln Tariff per tkm	St. error
= 1.7365	
+ 0.24 Direction Variable (to Karachi=0, from Karachi =1)	0.0191
- 0.5532 Ln Distance (km)	0.0264
+ 0.1976 Ln Time (hrs)	0.0233
- 0 7178 Ln Load Weight (tonnes)	0.0218
+ 0.3167 Ln New Vehicle Value (1000 Rs)	0.0287
N = 1388 $R^2 = 0.706$ t value = 25.8	

Excluding vehicle value and journey time

Ln Tariff per tkm	St. error
= 2.2672	
+ 0.2339 Direction Variable (to Karachi=0, from Karachi =1)	0.0205
- 0.3342 Ln Distance (km)	0.0109
- 0.5449 Ln Load Weight (tonnes)	0.0187
N = 1388 $R^2 = 0.659$ t value = 29.9	

5. THE EFFECT OF ROUGHNESS ON REVENUES FOR DIFFERENT ROUTES

The nationwide regression analysis presented in Section 4 has shown that small to moderate differences in roughness levels have little apparent effect on tariffs. The addition of survey data from the Mekran region of Baluchistan, where the roads have very high roughness levels, does provide a significant statistical relationship between road roughness and tariffs. (See Table A2 in the Appendix). Unfortunately however, the imbalance in traffic flows and high level of empty running recorded in the Mekran lead to serious bias in this analysis. To try to get over the problem, a comparison was made between the average expected revenues for two standardised round trips (which include empty running), one located in Baluchistan and one located on the rest of network. The Baluchistan route was between Karachi and Turbat (in the Mekran) which had an estimated average roughness of 12900 mm/km, measured on the BI scale. The other was synthesised from data derived from vehicles operating over comparable journey distances on the rest of the network in Pakistan (average roughness: 4800 mm/km).

Sixty eight vehicle trips were recorded in the Roadside Interview Survey along the rough route, 54 of which were loaded. Of these, 15 trips were by two-axle Bedford trucks and 39 trips were by two-axle Japanese trucks.

The majority of the trucks surveyed were based in the Mekran region which suggests that they plied this route regularly. Estimated trip distances for this journey varied between 650 and 870 kilometres. For journeys throughout the rest of Pakistan of between 500 and 1000 kilometres in length, trip data was collected for 330 Japanese and Bedford two-axle trucks. Within this category, 294 journeys were loaded and of these, 237 were two-axle Bedfords, and 57 were two-axle Japanese trucks. Table 5 gives a breakdown of the data used in the analysis.

From the data in Table 5 mean values of the expected revenue per kilometre and the expected revenue per tonne kilometre were calculated for a standardised complete round trip for each vehicle type. In the estimation of revenue per kilometre, empty running was taken into account using the loaded ratios found in the survey. The results are shown in Table 6.

Here and in the rest of the report the term 'revenue' is used when tariffs are added together to produce a statistic. 'Revenue per kilometre' refers to the revenue earned in a period divided by the total (loaded and empty) journey distance travelled.

Table 6 shows that revenue per kilometre was recorded to be 10 per cent and 24 per cent higher on the rough routes than on the smooth routes for Bedford and Japanese trucks respectively. Because of the lower average loads on rough routes the corresponding figures for tariffs per tonne kilometre are 63 per cent and 79 per cent higher.

TABLE 5

Truck Trip Data (1986 prices)

Route To/From Karachi		Rough To	Rough From	Smooth To	Smooth From
Two-axle Bedford trucks:-					
Loaded trucks		3	12	105	132
Empty trucks		5	0	14	8
Loaded ratio per cent		37.5	100	88.2	94.3
Mean loaded distance	km	781	726	726	698
Mean empty distance	km	627	-	719	751
Mean load	tonnes	5.5	8.3	8.0	8.7
Mean tariff	Rs.	900	4617	1980	2680
Two-axle Japanese trucks:-					
Loaded trucks		8	31	15	42
Empty trucks		9	0	12	2
Loaded ratio per cent		47.1	100	55.5	95.5
Mean loaded distance	km	876	649	748	847
Mean empty distance	km	676	-	667	704
Mean load	tonnes	7.2	9.4	11	13
Mean tariff	Rs.	2825	5597	3014	4381

TABLE 6

Expected Revenue Per Kilometre For Rough And Smooth Roads (1986 prices)

Road Type		Two-Axle Bedford Rough	Two-Axle Bedford Smooth	Two-Axle Japanese Rough	Two-Axle Japanese Smooth
Road roughness, (BI scale)	mm/km	12900	4800	12900	4800
Standardised distance	km	754	713	763	798
Expected load	tonnes	5.2	7.7	6.4	9.3
Expected revenue	Rs	2477	2136	3464	2930
Expected rev/km	Rs	3.29	3.0	4.54	3.67
Expected rev/tonne km	Rs	0.637	0.390	0.712	0.397

6. A COMPARISON OF DATA FOR ROUGH AND SMOOTH ROUTES WITH VEHICLE OPERATING COST MODEL PREDICTIONS

The data for the rough and smooth routes given in Section 5 were used in a comparison with predictions of costs derived from three sets of vehicle operating cost (VOC) models used for road investment appraisal. The VOC relationships derived from studies in Kenya and the Caribbean by the Overseas Unit, TRRL are incorporated into the Road Transport Investment Model, RTIM3 (Cundill, 1993). Vehicle operating cost model relationships were also derived from studies in Brazil and India. These are included as separate VOC options in the World Bank's Highway Design and Maintenance Model HDM3. The particular model relationships used here are derived from Chesher and Harrison (1987).

From the data collected in the main surveys, estimates of total lifetime operating costs for vehicles operating on the main roads of Pakistan are given in Table 7.

Key input assumptions relating to the VOC models are included in Table 8 . To be consistent with revenue data, market prices (including taxes and duties) are used for all items. The VOC models predict maintenance parts costs as a percentage of the new vehicle price where both

TABLE 7

Estimated Lifetime Operating Costs Per Kilometre (1986 prices)

	Two-Axle Bedford	Two-Axle Japanese	Three-Axle Japanese
Distance per day Kms	329	304	373
Running costs:		Rs per km	
Fuel	1.257	1.333	1.732
Crew	0.426	0.472	0.587
Maintenance and repairs	0.322	0.294	0.388
Tyres	0.142	0.142	0.213
Oil and grease	0.141	0.190	0.193
Loading labour	0.079	0.086	0.149
Octrol, police, taxes	0.171	0.193	0.183
Agents commission	0.078	0.115	0.110
Total running costs	2.616	2.825	3.555
Estimated capital costs	0.243	0.365	0.429
Net Profit	0.080	0.157	0.398
Total Revenue per km	2.939	3.347	4.382

TABLE 8

Key Assumptions For VOC Model Predictions (1986 prices)

		Two-Axle Bedfords	Two-Axle Japanese
All VOC Models:-			
Annual travel	kms	112,000	123,000
New vehicle price	Rs	325,000	390,000
Tyre price	Rs	2,275	2,275
Diesel price	Rs/ltr	4.3	4.3
Oil price	Rs/ltr	13.4	13.4
Crew cost	Rs/hr	13	13
Maintenance labour	Rs/hr	9.4	9.4
Interest rate	%	10	10
Gradient	m/km	0	0
Curvature	%	0	0
Engine power	H P	98	180
RTIM Only:-			
Mean age	Years	9.3	3.4
Vehicle value/new price	%	25	62
Overhead rate	%	20	20
Gross weight, rough/smooth	Kgs	10600/13100	11800/14700
HDM Only:-			
Mean life	Years	12	12
Tare weight	Kgs	5400	7000
Mean load, rough/smooth	Kgs	5160/7670	6380/925

parts and vehicles are priced without tax. Because the average tax rates on vehicles and parts were believed to be broadly similar no adjustments were made to equate the predicted maintenance parts costs to market price levels.

Data on gradients, curvature and superelevation were not collected; road roughness was the only key difference between rough and smooth roads examined by the models. Apart from the key input assumptions, advisory "default" options were used

The results of the model predictions are shown in Table 9. The table shows big differences between the model estimates of fuel consumption and maintenance costs. In the RTIM relationships, fuel consumption is very sensitive to gradient and clearly a major part of the difference in fuel consumption between the models relates to this. Because of the lack of reliable information on gradients it was decided to omit fuel consumption from the comparison.

Nearly all the main paved roads in Pakistan are flat and straight. The Mekran-Karachi road passes through two ranges of hills and naturally some gradients and curvature are present. However calculations show that model estimates of spare parts and tyre consumption would be only slightly affected by the inclusion of these gradients and curvature and so their effect can be ignored.

Fuel consumption data collected from the roadside interview survey on the rough and smooth routes are given in Table 10. These data are deducted from the revenues shown in Table 6 to give the observed

TABLE 9

Vehicle Operating Cost Predictions (Rs per Km, 1986 prices)

	Two-Axle Bedford		Two-Axle Japanese	
Road Type	Rough	Smooth	Rough	Smooth
RTIM:				
Fuel	0.612	0.581	0.597	0.587
Oil	0.107	0.054	0.107	0.054
Tyres	0.443	0.396	0.493	0.444
Maintenance parts	4.270	2.444	4.057	2.037
Maintenance labour	0.310	0.182	0.245	0.127
Crew	0.494	0.277	0.466	0.269
Depreciation	0.195	0.110	0.652	0.377
Interest	0.121	0.068	0.347	0.200
Overheads	1.310	0.822	1.393	0.819
RTIM total	7.863	4.934	8.357	4.913
HDM (Brazil):				
Fuel	1.344	1.345	1.499	1.618
Oil	0.071	0.053	0.071	0.053
Tyres	0.353	0.341	0.371	0.364
Maintenance parts	4.033	1.717	3.450	1.469
Maintenance labour	0.233	0.150	0.196	0.126
Crew	0.376	0.210	0.372	0.192
Depreciation	0.303	0.185	0.356	0.203
Interest	0.182	0.111	0.214	0.122
HDM (Brazil) total	6.895	4.112	6.528	4.146
HDM (India):				
Fuel	0.966	1.240	0.817	1.133
Oil	0.043	0.037	0.043	0.037
Tyres	0.397	0.293	0.360	0.272
Maintenance parts	1.069	0.382	1.003	0.366
Maintenance labour	0.745	0.310	0.634	0.268
Crew	0.290	0.290	0.264	0.264
Depreciation	0.141	0.141	0.325	0.325
Interest	0.096	0.096	0.221	0.221
HDM (India) total	3.747	2.790	3.667	2.886

TABLE 10

Observed Fuel Consumption (1986 prices)

Road Type	Two-Axle Bedford Rough	Two-Axle Bedford Smooth	Two-Axle Japanese Rough	Two-Axle Japanese Smooth
Fuel consumption Rs per km	1.483	1.233	1.534	1.290

revenues, without fuel consumption, shown in Table 11. Table 11 also lists operating costs, after subtraction of fuel consumption, predicted by the different models.

Table 11 demonstrates wide variations between the different estimates of costs and revenues. As expected the Indian relationships appear to provide the best estimates of revenues; the HDM (Brazil) and RTIM relationships predict costs that are up to four times the observed revenues.

In Pakistan, revenues must cover conventional operating costs, profits and items such as loading and unloading labour, octroi charges (a local tax collected on vehicle movements), freight agents' fees and gratuities paid to police. Typically these additional costs account for about ten per cent of the total revenues earned.

The analysis shows that all of the models considerably over-predict the effect of increased road roughness on operating costs. This is particularly marked for RTIM and the Brazilian relationships. The Indian relationships for the two-axle Japanese trucks provided the closest prediction of the differences in tariff levels between rough and smooth roads but even in this case the difference was overestimated by 43 per cent.

Reductions in vehicle maintenance costs comprise most of the benefits predicted by the models following reduced levels of road roughness. In comparing the model predictions with estimated levels of maintenance costs derived from empirical data (see Table 12 in section 7.3) it would appear that this particular component is substantially over-estimated. The reasons for the low levels of vehicle maintenance costs in Pakistan are probably because of the widespread network of skilled mechanics, the availability of low cost, locally manufactured spare parts, and slow driving speeds. Another factor, which may also have an effect, is that oil changes appear to be far more frequent in Pakistan than in other countries.

A comparison of the Indian operating cost predictions with the predicted lifetime costs also shows important differences in tyre consumption and crew costs. Tyre costs appear to be overestimated while crew costs are underestimated. Part of the explanation of the differences in tyre consumption may relate to the slow running speeds and the widespread use of secondhand re-moulded tyres in Pakistan. The differences in crew costs relate to the generally higher vehicle manning levels in Pakistan than in other countries.

7. TRENDS IN UTILISATION, REVENUE AND OPERATING COSTS WITH VEHICLE AGE

7.1 ANNUAL DISTANCE TRAVELLED

Three estimates of annual distance travelled have been calculated from the Roadside Interview Survey (See Table A4 of the Appendix). For two-axle Bedford trucks, the mean of the estimates given is 112,000 kms per year. Further general confirmation of these estimates was collected from the Vehicle Activity Survey and the Drivers' Diaries; in the former, two-axle Bedford trucks were estimated to travel 109,000 kms per year and in the latter 122,000 kms per year.

TABLE 11

Comparison Between Observed Revenues and Predicted Costs (Excluding fuel consumption component, Rs per kilometre, 1986 prices)

Route	Two-Axle Bedford Rough Route	Two-Axle Bedford Smooth	Two-Axle Bedford Difference	Two-Axle Japanese Rough Route	Two-Axle Japanese Smooth Route	Two-Axle Japanese Difference
Observed rev/km	1.803	1.766	+0.037	3.007	2.382	+0.625
RTIM cost/km	7.251	4.353	+2.898	7.760	4.326	+3.434
HDM (Brazil) cost/km	5.551	2.767	+2.784	5.029	2.528	+2.501
HDM (India) cost/km	2.781	1.550	+1.231	2.850	1.753	+1.097

Using data from the Roadside Interview Survey, an analysis was carried out to determine how annual travel is influenced by vehicle age. Two estimates of annual travel were used for this analysis. One estimate was based on the drivers' own estimates of their normal weekly travel (adjusted for days off the road under repair) and a second estimate was derived from the current trips of loaded trucks using the time and distance taken for the current loaded journey and from any previous empty trip undertaken. (Both types of estimate were used to calculate the mean annual distance travelled shown in Table A4 discussed above.) The results of this analysis are shown in Table A5 of the Appendix.

The regressions given in Table A5 show that vehicle age has a very significant effect on annual travel, although it accounts for a relatively small proportion of the total variation. When estimating their annual travel, drivers tend to iron out their day-to-day fluctuations and so a closer relationship can be expected between age and the drivers' own estimates of annual travel than between vehicle age and the estimates based on current trips. This is confirmed by the analysis.

Vehicle age affects the utilisation of the two-axle Japanese trucks far more than Bedford trucks. For example, by applying the regression equations for the data sets derived from the drivers' own estimates of annual travel, it can be calculated that after ten years, the distance travelled per year will decline by 42 per cent for two-axle Japanese trucks and only 13 per cent for the Bedford trucks. Mean estimates of annual distance travelled for Bedford trucks and two-axle Japanese trucks are given in Figure 5.

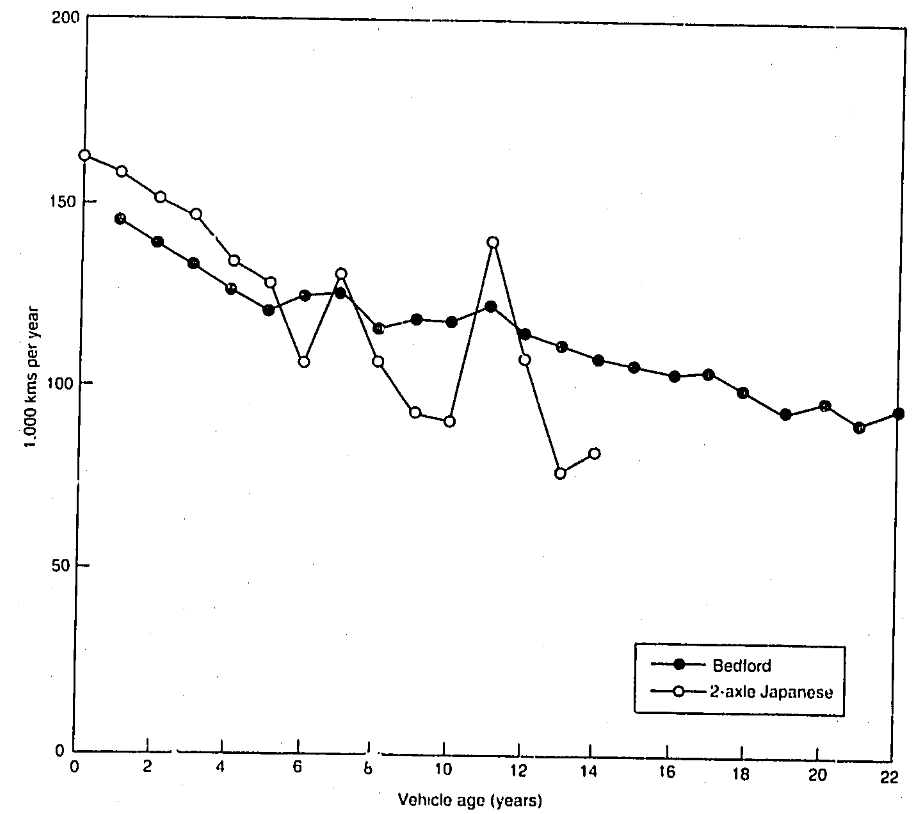

Fig. 5 Distance travelled per year

7.2 REVENUE

Data on vehicle earnings was collected from the Roadside Interview Survey, Drivers' Diaries, and from the Vehicle Activity Survey. Estimates of earnings per day from the different surveys is given in Research Report 314. The estimates of mean revenue per day for the two-axle Bedford trucks range from 967 to 1086 Rs per day; a difference of about 12 per cent. Based on information from the main Roadside Interview Survey, estimated mean revenue per day for two-axle Japanese trucks was 1171 Rs; for three-axle Japanese trucks 1864 Rs; and Japanese Tractor-Trailers 1917 Rs. Because of the smaller sample sizes, there is greater uncertainty concerning the estimates of revenue per day for the larger trucks.

As a vehicle ages, it can be expected that distance travelled and revenue earned will decline. The regression analysis presented in Table A5 and discussed above found that annual distance travelled did decline with vehicle age for Bedford and two-axle Japanese trucks. However using data from the Roadside Interview Survey no significant relationship was found between revenue per day and vehicle age for Bedford trucks. This is principally explained by a rise in revenue per kilometre with age as older vehicles are diverted towards shorter routes. Nevertheless revenue per day will almost certainly decline towards the very end of a vehicle's life as it becomes very unreliable. The oldest and least reliable vehicles tend to be used most on short distance urban routes. These vehicles may not have been detected because intra-district traffic was omitted from the Roadside Interview Survey.

In contrast to the results for the Bedford trucks, revenue per day for the two and three-axle Japanese trucks was found to decline with vehicle age as annual distance travel fell. For these vehicles, it was calculated that revenue per day would decline by about one third after ten years. No significant relationship was found between age and revenue per kilometre. It is difficult to explain the differences in operating performance found between the Bedford and the Japanese two and three-axle trucks.

An analysis of revenue per kilometre and revenue per day was carried out using data for Japanese tractor-trailer vehicles. No significant relationships were found.

7.3 REPAIR AND MAINTENANCE COSTS

It is generally accepted that vehicle repair costs will vary with vehicle age and road condition. A summary of data collected on repair costs is shown in Table 12. As expected, vehicle repair costs were found to have a high degree of variability. The mean estimates reported from the Diaries are lower than the estimates from the Roadside Interview Survey. In part this can be explained by the lower vehicle age of the Diary Data. Bedford trucks travelling on the mountainous northern routes appear to have higher repair costs than those trucks travelling on flatter terrain. The Japanese trucks travelling on the rough roads in the Mekran were also reported to have higher repair costs although this was not the case for the Bedford trucks. Some of the differences in costs may be obscured by differences in age structure; this is examined in greater detail below.

To determine the effect of vehicle age on repair costs a series of regressions were carried out using data from the Roadside Interview Survey; the results are given in Table A6 in the Appendix. This analysis showed that age can account for only a small proportion of the total variation in repair costs although for two-axle Bedford and Japanese trucks the regressions relating repair costs per kilometre to vehicle age are significant. The repair costs (per km) of the two-axle Japanese trucks are shown to start at a lower base but to grow more quickly than the repair costs of the Bedford trucks. No significant trends could be identified between repair costs per day and vehicle age; this is probably because the higher repair costs per kilometre are compensated by lower annual travel as the vehicle ages. In Figure 6 the mean repair costs (per km) are plotted against vehicle age for the two-axle Bedford and Japanese trucks.

The regressions given in Table A6 show that the repair costs of two-axle Japanese trucks operating on the rough roads in the Mekran increase at a much faster rate than for those operating in the rest of the country. In contrast, no significant relationship could be found between repair costs and vehicle age for the Bedford trucks operating in the Mekran.

Spare parts for the Bedford truck were found to be widely available all over Pakistan. In the larger towns original parts for the Japanese trucks were also found to be available. Many parts for the Bedford are manufactured in Pakistan and in most cases if a part is not at hand it can be made at one of the numerous small workshops. A small survey of vehicle spare parts was carried out in Rawalpindi and Lahore. It was found that Japanese truck parts were on sale at about three times the price of the equivalent for a Bedford truck.

TABLE 12

General Repair and Maintenance Costs (Rs per km, 1986 prices)

	Two-Axle Bedfords	Two-Axle Japanese	Three-Axle Japanese	Tractor-Trailers Japanese
Diary Data:				
mean	0.239	0.244	0.315	
St. Error	0.015	0.03	0.04	
mean vehicle age	4 yrs	1 yr	1 yr	
Roadside Interview Survey:				
Excluding trucks operating on rough or mountainous terrain				
mean	0.358	0.259	0.367	0.568
St. Error	0.005	0.009	0.036	0.043
mean vehicle age	10 yrs	3 yrs	3 yrs	4 yrs
Trucks operating on mountainous northern routes				
mean	0.573			
St. Error	0.025			
mean vehicle age	11 yrs			
Trucks operating on rough roads in Mekran				
mean	0.351	0.31		
St. Error	0.028	0.031		
mean vehicle age	9 yrs	2 yrs		

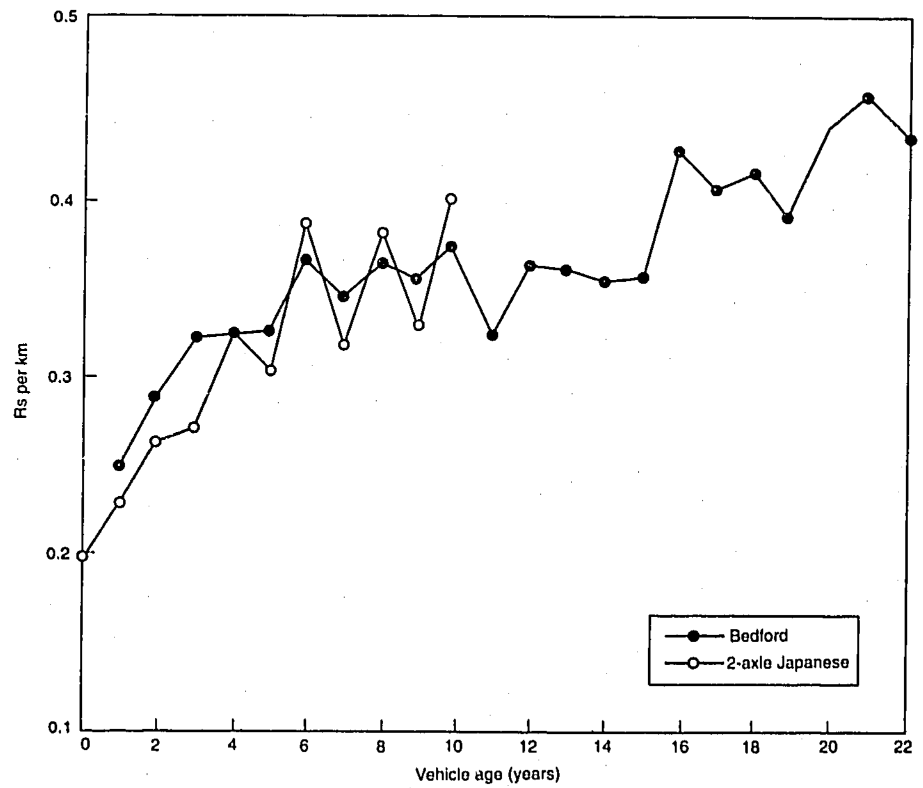

Fig. 6 Truck repair costs

8. VEHICLE PROFITABILITY AND TRIP DISTANCE

An analysis of vehicle profitability is reported in Research Report 314. Assuming that the overall revenues and costs will be maintained in real terms in the future for vehicles of different ages it was estimated that the two-axle Bedford trucks were just profitable (IRRs in the range 6-9 per cent). Other truck type were found to be more profitable than the Bedfords; the three-axle Japanese trucks were found to be the most profitable of all (IRRs 50-70 per cent).

Using the data collected, an investigation was made on how profitability changes with trip distance. Figure 7 shows this relationship for two-axle Bedford trucks.

The analysis indicated that for long distance trips the two and three-axle Japanese trucks were profitable while the Bedford trucks were not. This confirms the widely held view that trucks with small carrying capacity are more suited to short distance journeys where their flexibility is an advantage.

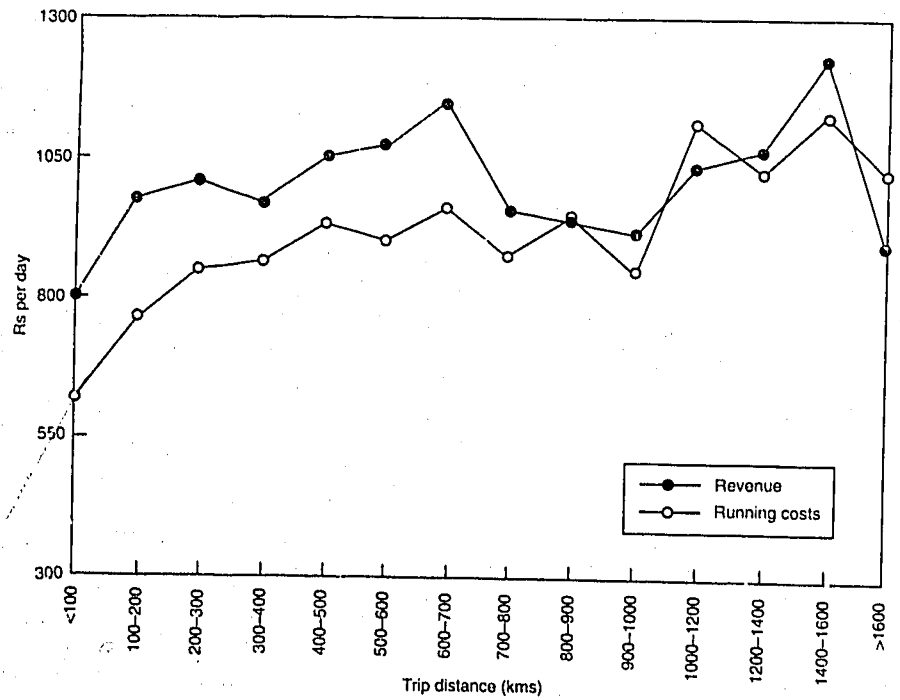

Fig. 7 Revenue and costs of Bedford trucks

9. SUMMARY

An analysis of trends in freight tariffs over the period from 1982 to 1986 showed that tariffs rose closely in line with general price inflation. A small, but distinct, seasonal pattern in tariff levels was found. For journeys outbound from Karachi tariffs were above the mean by about 0.75 per cent for the first half of the year and they were below the mean by just over 1 per cent during the latter half. The pattern of tariffs for journeys in the opposite direction followed an almost a mirror image of this with lower tariffs in the first half and higher tariffs in the latter half of the year.

The effects of distance, time, travel direction, load weight and vehicle type on tariffs was investigated through the use of regression techniques. A high degree of explanation of the variability in tariff levels was found using a log-log multiple regression (overall $R^2 = 0.84$). The effect of journey distance was consistently found to be much greater than the effects of journey time. Small and moderate changes in road roughness were found to impose no significant effect on tariffs.

To examine the effect of large differences in road roughness on revenues, (and allowing for differences in empty running) a comparison was made between a very rough route in the Mekran (13,000 mm/km) and routes on the rest of the main road network (4,800 mm/km). On the rough route, revenues per vehicle kilometre were estimated to be 10 per cent higher for 2-axle Bedfords and 24 per cent higher for 2-axle Japanese trucks. However because of the lower loads carried on the rough route, revenues per tonne km were 63 per cent and 79 per cent higher for the Bedford and Japanese trucks respectively.

The revenue data were then compared with estimates derived from standard models of VOCs used for road appraisal in developing countries. Measured on a cost per kilometre basis, and excluding fuel consumption, both the RTIM model and the HDM Brazil model of VOCs were found to substantially overestimate the costs (and tariffs) found for trucks operating in Pakistan. The HDM Indian model was found to give fairly close results for smooth roads; however in common with the other models, it also appeared to overestimate costs and tariffs for very rough roads. Hence there were good grounds to believe that all three models would overestimate the reductions in the per kilometre vehicle operating costs from improving unsurfaced roads in Pakistan. However corrections would also be needed to take account of the greater loads carried by vehicles on smooth roads.

Repair costs were found to increase, and annual distance travelled was found to decrease with vehicle age, although age could account for only a relatively small proportion of the variation found in these items. For two-axle Japanese trucks, revenue per day was found to decline with vehicle age although no similar trend was observed for two-axle Bedford trucks.

Indications were found to suggest that long distance trips were unprofitable for the two- axle Bedford trucks. In contrast long distance trips were found to be more profitable for the two and three-axle Japanese trucks which have a larger carrying capacity than the standard Bedford truck.

10. ACKNOWLEDGEMENTS

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APPENDIX

TABLE A1

Common Trucks In Pakistan

Vehicle Make	Model Kg	Type Kg	Axles	GVW*	GCW**	HP	Price Rs. Sept 1986
Bedford	CJP	Rigid	2	10,920	n/a	98	275,000
Bedford	TM2500	Tr. Unit	2	n/a	25,000	171	n/a
Hino	FF 170	Rigid	2	n/a	n/a	200	412,000
Isuzu	JCR/FTR	Rigid	2	12,000	n/a	160	398,000
Isuzu	TDJ/DVR	Rigid	2	15,000	27,000	220	515,000
Mitsubishi	FP415ER	Tr. Unit	2	15,400	39,000	310	730,000
Nissan	TK20GT	Tr. Unit	2	14,175	26,000	190	570,000
Nissan	TK20	Rigid	2	16,500	26,000	190	475,000
Nissan	TD10	Rigid	3	23,000	n/a	160	480,000
Nissan	U780E	Rigid	2	12,000	n/a	140	342,000

* Gross Vehicle Weight
**Gross Combination Weight
Source: Manufacturers Specifications

TABLE A2

The prediction of freight tariffs for different vehicle types, including Mekran data

		St. error
Ln Tariff	= 0.787	
	+ 0.2605 Direction Variable (to Karachi=0, from Karachi =1)	0.0195
	+ 0.4417 Ln Distance (km)	0.0268
	+ 0.1919 Ln Time (hrs)	0.0241
	+ 0.2808 Ln Load Weight (tons)	0.022
	+ 0.3426 Ln New Vehicle Value (1000 Rs)	0.0284
	+ 0.1845 Ln Road Roughness[1] (BI:mm/km)	0.0359

N = 1451 $R^2 = 0.832$ t value = 34.5

[1]. Note this coefficient is considered unreliable because of the high degree of empty running on very rough roads (see main text).

TABLE A3

The prediction of freight tariffs per vehicle kilometre for different vehicle types, excluding cases with road roughness > 10,000 mm/km

Variable to predict: Ln Tariff/km	Two-Axle Bedfords	Two-Axle Japanese	Three-axle Japanese	Tractor Trailers
Constant	3.5488	2.3303	2.0328	3.3027
Direction	.2211	.1287	.3122	.6645
	(.021)	(.056)	(.066)	(.082)
Ln Distance	-.5651	-.4308	-.3319	-.5352
	(.029)	(.084)	(.062)	(.126)
Ln Time	.1984	.1604	not sig.	.2392
	(.026)	(.07)		(.092)
Ln Load Weight	.2165	.5227	.5811	.2761
	(.024)	(.083)	(.097)	(.117)
N	1030	197	81	80
R^2	.564	.288	.625	.652
t value	18.2	4.4	6.5	5.9

(Note: standard errors in brackets, all units as in Table A6)

TABLE A4

Three Estimates of Annual Distance Travelled (1000 kms)

	Two-Axle Bedford	Two-Axle Hino	Two-Axle Isuzu	Two-Axle Nissan	Three-Axle Nissan	Tractor-Trailer Nissan
i) based on weekly distance	117	159	147	132	143	136
ii) based on trip revenues*	109	116	104	95	112	129
iii) based on trip times	109	129	117	108	120	127
Mean of estimates	112	135	125	112	125	131

Source: Roadside Interview Survey
* Excludes data from Survey Stations 1 - 11.

TABLE A5

The Felationship Between Annual Distance Travelled and Vehicle Age (in years)

Two-Axle Bedford Trucks		
Kilometres per year = 141,629 - 1816 Vehicle age (se= 170)		N = 1848
R^2 = 0.058,	t value = -10.7	
Two-Axle Japanese Trucks		
Kilometres per year = 166,253 - 6923 Vehicle age (se = 821)		N = 434
R^2 = 0.14,	t value = -8.44	
Three-Axle Japanese Trucks		
Kilometres per year = 154,977 - 2957 Vehicle age (se = 1610)		N = 75
R^2 = 0.045,	t value = -1.837	

Source: Roadside Interview Survey

TABLE A6

The Relationship Between Repair Costs and Vehicle Age (Age in years, 1986 prices)

Two-Axle Bedford Trucks		
Repair cost per km	= 0.303 + 0.0058 Vehicle age (se= 0.0009)	N = 1977
R^2 = 0.02,	t value = 6.437	
Two-Axle Japanese Trucks		
Repair cost per km (excluding trucks operating on rough or mountainous routes)		
	= 0.219 + 0.0168 Vehicle age (se= 0.0037)	N = 348
R^2 = 0.06,	t value = 4.57	
Repair cost per km (trucks operating on rough routes in the Mekran area)		
	= 0.17 + 0.07 Vehicle age (se = 0.02)	N = 74
R^2 = 0.15,	t value = 3.53	
Three-Axle Japanese Trucks		
Repair cost per km = 0.317 + 0.0195 Vehicle age	(se = 0.015)	N = 107
R^2 = 0.016,	t value = 1.3	

Source: Roadside Interview Survey

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