POSSIBILITY OF A SHIFT FROM PRIVATE TO COMMERCIAL TRUCKS

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ABSTRACT

In this paper, we discuss the possibility of a shift from private to commercial trucks, analyzing the behavior of cargo shippers with statistics on physical distribution data for the year 2000, and clarify the factors involved in the choice of type of trucks by distance, item and so on. These analyses were conducted by means of discriminant analysis. As a result, we found that aside from certain items, a considerable portion of private trucks can be converted to for-hire trucks. Furthermore we estimated the feasible scale of the shift. The greater the increase in commercial trucks, the more loading efficiency would improve, and this in turn would lead to a reduction in CO2 emissions. We were able to estimate a hypothetical reduction of approximately 17 percent in CO2 emissions via a shift from private trucks to for-hire trucks.

INTRODUCTION

Road freight transport in Japan has been characterized by an increase in private owner-driven truck operations for domestic freight traffic. Private trucks carry nearly half of freight tonnage, especially over short-distance hauling, though these vehicles are less efficient and cause more damage to the environment. The prevalence of less efficient private trucks is one of the major causes of energy inefficiency in the traffic sector. A conversion from private to commercial trucks would make it possible to bring about improved cargo efficiency and a reduction in empty vehicles. In view of environment and transport efficiency factors, a shift from private trucks to commercial trucks is desirable.

Although a great deal of literature on a possible modal shift from road traffic to railway or marine traffic has appeared in a number of journals, there are few studies on a shift from private vehicles to commercial trucks. One of the reasons for this is that data on private trucks and for-hire trucks is currently unavailable. Fortunately, however, census data on freight truck ownership in Japan could be collected.

In this paper, we discuss the possibility of a shift from private to commercial trucks, analyzing the behavior of cargo shippers with statistics on physical distribution data for the year 2000, and clarify the factors involved in the choice of type of trucks by distance, item and so on. These analyses were conducted by means of discriminant analysis.

As a result, we found that aside from certain items, a considerable portion of private trucks can be converted to for-hire trucks. Furthermore we estimated the feasible scale of the shift. The greater the increase in commercial trucks, the more loading efficiency would improve, and this in turn would lead to a reduction in Carbon Dioxide (CO_2) emissions. It was found that a hypothetical reduction of approximately 17 percent in CO_2 emissions via a shift from private trucks to for-hire trucks can be achieved.

COMMERCIAL AND PRIVATE TRUCKS

The volume of Japan's domestic cargo transportation for fiscal 2000 came to 6.4 billion tons, or 573.2 billion ton-kilometers, of which trucks carried 90.6% in tonnage, or 54.2% in terms of ton-kilometer. This breakdown in modal share is as follows: 46.0% by commercial trucks, 44.6% by private trucks, 0.9% by rail, 8.4% by marine, 0.0% by air in ton, and 44.2% by commercial trucks, 10.0% by private trucks, 3.8% by rail, 41.8% by marine, 0.2% by air in ton-kilometers.

Table 1 shows the comparisons of transport efficiency between commercial and private trucks. As shown in this table, despite the small percentage of the number of vehicles, commercial trucks carried 50.8% in tonnage, or 81.6% in ton-kilometers of all truck cargoes for fiscal 2000. In terms of the actual ton-kilometers per day per truck, an indicator of the transportation efficiency of the truck, the commercial trucks are found to be approximately twenty times more efficient than private trucks. Such remarkable efficiency of the commercial trucks leads to the improvement of load factor and energy consumption. Furthermore, it also leads to the reduction of CO_2 emissions per ton-kilometer. From the standpoint of these aspects, it is recommended that a switch be made from the private owner-driven trucks to commercial trucks.

The commercial truckers fall into two broad categories: less-than-truckload (LTL) and truckload (TL) carriers. The former is a for-hire carrier for less-than-truckload shipments of general commodities and package delivery. We call this a "consolidated truck." The latter type of commercial truck is a full truckload shipment carrier. We call this a "chartered truck." The two types are very different. TL service is direct: The truck picks up freight at the shipper's depot and delivers it to the consignee's location. A TL truck carries only one customer's goods on board. LTL freight is picked up, taken to a terminal where it is consolidated with other freight bound for the same destination, then carried by a line-haul truck to a terminal near the destination city. It is then finally delivered by another truck. Small package and LTL truck operations typically consolidate multiple shipments for transport by a single vehicle.

Item	Unit	Commercial	Share (%)	Private	Share (%)
Number of vehicles	Mil.	110.5	13.6	700.1	86.4
Distance traveled	Mil. km	69,204	37.3	116,728	62.7
Freight tonnage carried	Ton	2,916	50.8	2,713	49.2
Freight ton-kilos carried	Bil.ton-km	255	81.6	56	18.4
Actual distance traveled per day per truck	Km	233	--	75.7	--
Average haulage distance per ton of cargo	Km	87.4	--	20.6	--
Actual haulage distance per day per truck	Ton-km	821.8	--	40.5	--

(Source: Japan Trucking Association)

Table 1. Comparisons of transport efficiency between commercial and private trucks
(For fiscal 2000)

DISCRIMINANT ANALYSIS

For clarification of the factors involved in the choice of type of truck, we carried out discriminant analysis. For every pair of these modes in truck operations, (between the private trucks and the chartered trucks, between the private trucks and the consolidated trucks, and between the chartered trucks and the consolidated trucks), 2-group stepwise discriminant analysis was performed by item, respectively. The explanatory variables were entered in a stepwise fashion using Wilks' lambda criterion.

$$z_j = a_{0j} + a_{1j}x_{1j} + a_{2j}x_{2j} + \cdots + a_{nj}x_{nj} \qquad j \in M \qquad (1)$$

z_j : discriminant score of item j

M : set of items

x_{ij} : the ith explanatory variable for item j, or the binary variable in dummy variable

a_{ij} : discriminant weight or coefficient, a measure of the extent to which variable x_{ij} discriminates among the groups of the dependent variables for item j

a_{oj} : discriminant constant for item j

n : number of explanatory variables

The eight item categories targeted by our study are as follows: 1) agriculture and fishery products, 2) forestry products, 3) mineral products, 4) metal and machine products, 5) chemical products, 6) light-industries products, 7) miscellaneous manufactured products, and 8) special products. We first listed the following factors as explanatory variables: Attribution of consignors (mining, manufacturing industry, wholesale business, and warehousing), attribution of consignees (factory, commercial warehouse, private warehouse, wholesaler,

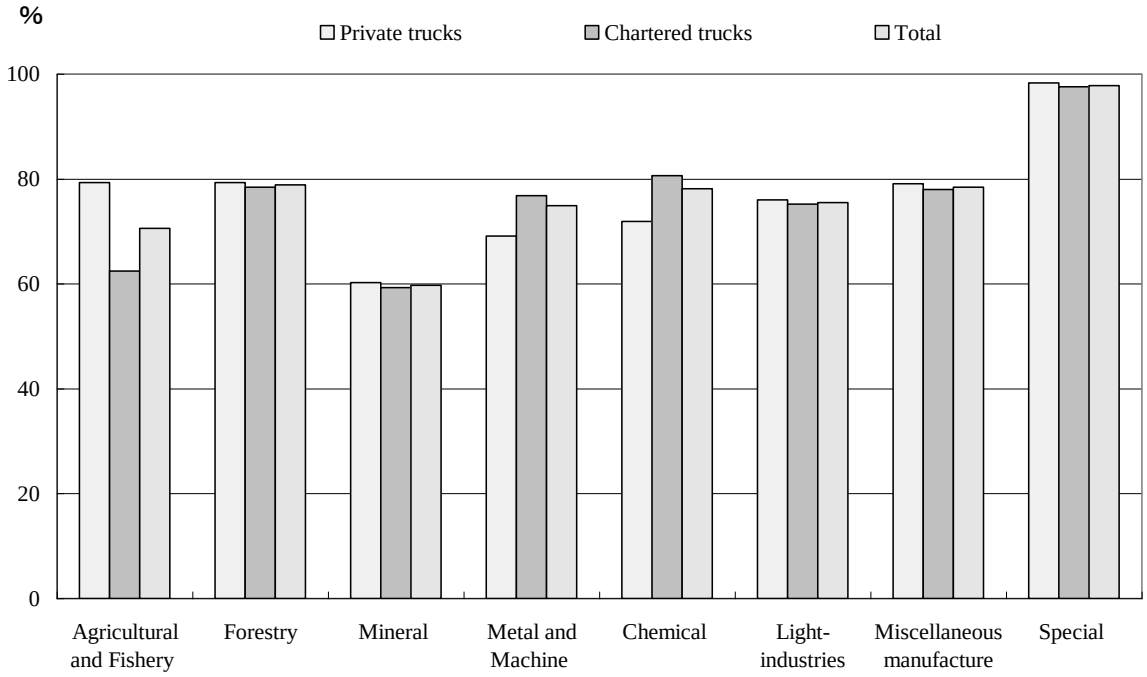

Figure 1. Results of discriminant analysis between private and chartered trucks by item and by mode

Freight modes		Discriminant rates		
M_1	M_2	Total	M_1	M_2
Private [-0.981]	Chartered [0.323]	74.9 (44969)	71.9 (11129)	80.6 (33840)
Private [-1.744]	Consolidated [0.584]	88.5 (44387)	89.8 (11129)	92.2 (33258)
Consolidated [0.586]	Chartered [-0.576]	81.5 (67098)	77.2 (33258)	85.3 (33840)

M_1, M_2;Freight mode ( );Number of data [];Gravity values

Table 2. Discriminant rates of metal and machine products

retailer, construction site, recycling center, private residence, and others), time required, size of freight lot (weight per unit), transportation distance, the distance between interchanges in the case of super highways, and accessibility to super highway interchanges. Significant variables for discrimination are selected out of these variables by stepwise discriminant analysis.

RESULTS OF DISCRIMINANT ANALYSIS

It was possible to use various census data on freight trucks from the 7th National Freight Transportation Survey (A three-day-survey conducted by Ministry of Land, Infrastructure and Transport in the year 2000). SPSS (version 11.5j) was used as the software for stepwise discriminant analysis. SPSS provides two methods for building a discriminant model. One involves entering all the given variables simultaneously, and the other is a stepwise method. In our study, the variables were selected in a stepwise fashion using Wilks' lambda criterion and Mahalanobis's distance is used for discrimination of groups.

	Coefficients	F-values
Wholesale	-1.505	6,186
Warehousing	0.736	4,331
Factories	-0.340	3,359
Commercial warehouse	0.239	1,290
Wholesaler	-0.193	1,094
Construction site	-0.228	1,994
Private residence	-1.984	2,313
Other site	0.147	1,184
Time required	0.007	1,754
Size of freight lot	0.005	2,751
Distance traveled	0.312	8,540
Distance traveled on highway	0.145	1,415
Accessibility to interchange	-0.893	1,564
(Constant)	-0.672	--

Table 3. Discriminant coefficients and F-values of metal and machine products between private and chartered trucks

Figure1 shows the results of discriminant analysis between private and chartered trucks by item and by mode. Table 2 shows the discrimination rates (hit ratios), number of data and discriminant scores for metal and machine products. Table 3 shows the explanatory variables, which were selected in stepwise fashion, and their discriminant coefficients for discrimination between the private and the

Agricultural and Fishery	Forestry	Mineral	Metal and Machine
10/53	13/50	58/69	17/55
Chemical	Light-industries	Miscellaneous manufactured items	Special
9/26	11/44	8/33	3/1

Number/Ton-km

Table 4. Possible rates of shift by item (%)

chartered trucks.

Hit ratios are relatively high and discriminations between all combinations of two groups seem to be observable. We see from Table 2 that the discrimination between the private and the consolidated trucks is clearer than those of the other pairs, because the hit ratio for the discrimination between that pair is the highest. This means that they have different attributes and it is rather difficult to switch from the private to the consolidated trucks. To the contrary, it is highly possible that a shift can be made from private to chartered trucks since those two have rather much in common. When we observe the discriminant coefficients of the variables in Table 3, we can find the degree of the discrimination for variables between the private trucks and the chartered trucks. Consignors tend to prefer the chartered trucks in case of long-distance hauling and carrying cargo dispatched from warehouses. In the case of transport from wholesale as origins, to factories and construction sites as destinations and large size of freight lots, the private trucks are preferred.

SHIFT TO FOR-HIRE TRUCKS AND REDUCTION OF CO_2 EMISSIONS

We estimated the possible volume of freight transport which can be shifted to for-hire trucks from the private trucks using the results of the discriminant analysis. When we misclassified the freight by the private trucks as that by for-hire trucks in the discriminant analysis, the volume, which was not correctly classified, seems to have the attributes associated with for-hire trucks. We regard this volume as feasible for shifting from private to commercial trucks. When this volume was converted to a ratio, the shifted rate for metal and machine products accounted for 17% in number and 55% in ton-kilometers. Table 4 shows the volume of feasible shift for overall items. We see from this table that the shift from private to chartered trucks is dominant.

A conversion from private to commercial trucks would make it possible to bring about improved cargo efficiency and a reduction in empty vehicles. As a result of that, it becomes possible to reduce the emissions of CO_2 in the transportation sector. Based on the volume of freight transport shifted to commercial trucks, we can estimate the volume of reduction of CO_2 emissions. Table 5 shows changes in the volume of CO_2 emissions by the shift

	Current	After	Changes
Private trucks	9,379	6,876	-2,503
Commercial trucks	4,059	4,299	240
Total	13,438	11,175	-2,263

Table5. Changes in CO_2 emissions by shift (10000ton/year)

to commercial trucks. These figures were calculated using the basic unit volume of the emissions of CO_2 per ton-kilometer of vehicles. Consequently, when a shift to business purposes is performed, the amount of reduction of CO_2 emissions is estimated at 22,630,000t per year, and this is equivalent to a 16.8% decrease in the current level.

Thus, in view of the environment and transport efficiency factors, a shift from private trucks to commercial trucks is desirable.

CONCLUSION

In this paper, we first analyzed the possibility of a shift from private to commercial trucks using statistics on physical distribution data throughout Japan for the year 2000, and clarified the factors involved in the choice of type of trucks by distance, item and so on. These analyses were conducted by means of discriminant analysis. As a result, we found that aside from certain items, a considerable portion of private trucks can be converted to for-hire trucks. Furthermore we estimated the feasible reductions of CO_2 emissions by the degree of the shift. The greater the increase in commercial trucks, the more loading efficiency improvement and this, in turn, would lead to a reduction in CO_2 emissions. Consequently, it was found that the modal shift to commercial trucks has results in a reduction in CO_2 emissions of about 17 percent compared to the present level. The Third Conference of Parties to the 1992 United Nations Framework Convention on Climate Change held in Kyoto in 1997 (COP3) pursued this as the highest priority issue in environmental protection. The Japanese government set a goal for 6% reduction target for Japan at the Conference. Japan must reduce its greenhouse gas emissions from 2008 through 2012 by 6% compared to 1990 levels. In order to accomplish this goal, measures for CO_2 discharge control were prepared for each industrial sector, and for the physical distribution sector. We hope that the results of our study will contribute to attainment of this goal. Along with the shift from private trucks to commercial trucks, a modal shift from trunk-line transport via large trucks to transport via railways and ships should also be promoted and also introduction of natural gas-powered vehicles which emit approximately 20% less CO_2 than diesel trucks should also be promoted as much as possible.

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