PERIODICA POLYTECHNICA SER. TRANSP. ENG. VOL. 21, NO. 2, PP. 149-154 (1993)

DELIVERY VAN ROUTES DENSITY DISTRIBUTION

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Received: Nov. 9, 1992

Abstract

A data bank has been made of the routes along which delivery vans are used, the garages of which are located in Cracow and its closest vicinity (cca 1 million citizens). The data cover nearly 15000 routes. A statistical analysis has been made taking into account the type of user, season of the year, time of day, vehicle load and route length.

Keywords: characteristics of routes, density distribution.

In the paper, some results of statistical identification are shown concerning the characteristics of routes along which delivery vans are used in large urban complexes and vicinity. The investigation was stimulated by the idea of creating a model of a typical set of routes that would serve as a pattern (test) of real conditions of vehicle operation. This model was used with the method (worked out by the authors of the paper) of power transmission ratios optimization and ways of their application in view of fuel consumption economy.

A data bank has been made of the routes along which delivery vans are used, the garages of which are located in Cracow and its closest vicinity (cca 1 million citizens). The data cover nearly 15000 routes. A statistical analysis has been made taking into account the type of user, season of the year, time of day, vehicle load and route length. *Table 1* shows the distribution of the number of delivery vans used in socialized companies, the users divided into activity branches (see also *Fig. 1*). The number of these vehicles is 45% of all the delivery vans used in the Cracow district. The data base of delivery vans real routes covers four of the user branches shown in *Table 1* (no. 1, 3, 4, 6).

For research in each group of users, the number of vehicles chosen was proportional to the number of vehicles exploited. Next, information on the length of routes and various periods of exploitation was collected for the selected vehicles. From the point of view of mathematical statistics, the choice of data on the real vehicle routes has the characteristics of the choice

Table 1
Number of delivery vans used by socialized companies in the Cracow district (data for 1985)

No.	User branch	No. of vans used	Percentage
1	Material production companies	853	20.7
2	Non-production companies	449	10.8
3	Transport, Commerce, Communications	1412	34.2
4	Agriculture	203	4.9
5	Building	895	21.7
6	Others	320	7.7
	Total	4132	100.0

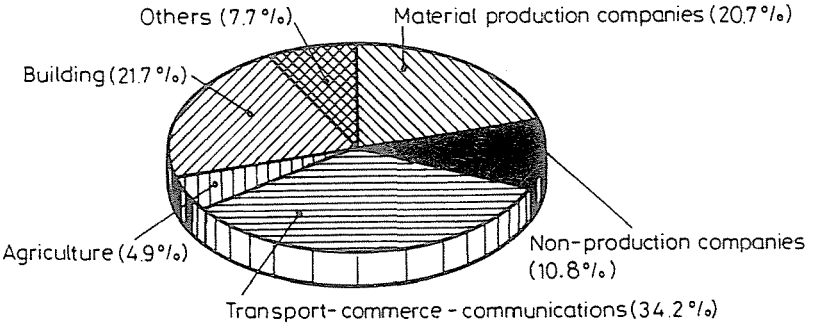

Fig. 1.

of sample as a result of laminar proportional sampling [1], [3], (vehicles) and group sampling [2] (routes). General data on the test are included in *Table 2.*

The vehicle route is characterized by:

- length in km,
- season of the year (winter and summer),
- vehicle loading state (loaded, unloaded),
- time of day (heavy traffic period between 5 am and 5 pm, the other hours).

Table 2
Characteristics of the test serving as the basis for the data bank on the real route lengths of the vehicles exploited

No.	User branch	Vehicles used totally	per cent	Vehicles tested	Number of routes
1	Material production companies	853	30.6	2	2608
2	Transport, Commerce, Communications	1412	50.6	5	3884
3	Agriculture	203	7.3	2	6009
4	Others	320	11.5	2	2286
	Total	2788	100.0	11	11787

The results were grouped into classes of variable intervals thus creating empirical distribution patterns of the route length frequency in given intervals. The density of these distribution patterns is shown in *Tables 3–6* and *Figs. 2–5.*

Table 3
Empirical distribution of delivery vans route length

	Relative frequency of random variable realization for route length intervals in km							
Branch	0–2	3–5	6–8	9–11	12–25	26–40	>40	amount
1	0.163	0.159	0.073	0.063	0.274	0.230	0.039	2608
2	0.021	0.370	0.192	0.038	0.027	0.026	0.326	3884
3	0.053	0.186	0.110	0.350	0.190	0.086	0.025	6009
4	0.151	0.262	0.241	0.083	0.111	0.101	0.051	2286
Total	0.079	0.242	0.145	0.176	0.149	0.098	0.111	14787

Table 4
Empirical distribution of length of rides with a load

	Relative frequency of random variable realization for route length intervals in km							
Branch	0–2	3–5	6–8	9–11	12–25	26–40	>40	amount
1	0.195	0.172	0.086	0.075	0.220	0.216	0.036	2077
2	0.020	0.388	0.193	0.038	0.026	0.023	0.312	3613
3	0.046	0.165	0.097	0.382	0.196	0.088	0.026	5500
4	0.113	0.230	0.219	0.071	0.136	0.149	0.082	1305
Total	0.070	0.238	0.136	0.199	0.144	0.097	0.116	12495

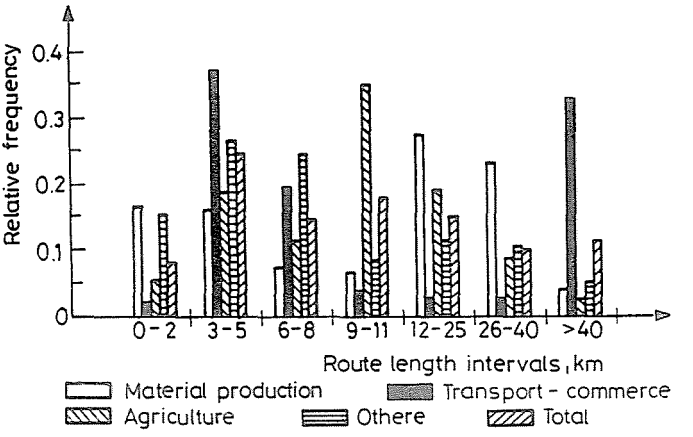

Fig. 2.

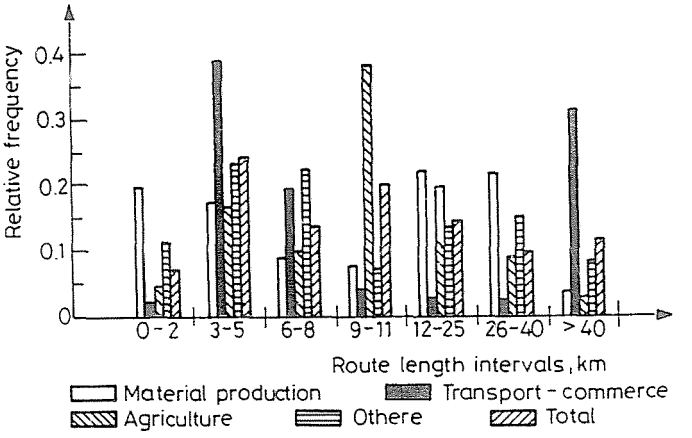

Fig. 3.

On the basis of the data included in *Tables 3–6*, it is possible to formulate a statistical model of vehicle exploitation. From the point of view of mathematical statistics, these data can be treated as test results. Since the test represents well the features of the population and is sufficiently sizeable (over 14 thousand observations), it can be treated as a representative test [1, 3].

Table 5
Empirical distribution of delivery vans route length in winter

Branch	Relative frequency of random variable realization for route length intervals in km							
	0–2	3–5	6–8	9–11	12–25	26–40	>40	amount
1	0.143	0.156	0.095	0.060	0.293	0.242	0.031	1280
2	0.024	0.399	0.123	0.045	0.034	0.037	0.338	1758
3	0.061	0.219	0.130	0.303	0.175	0.099	0.013	1299
4	0.161	0.282	0.260	0.089	0.106	0.061	0.041	2091
Total	0.100	0.276	0.159	0.115	0.137	0.098	0.115	6418

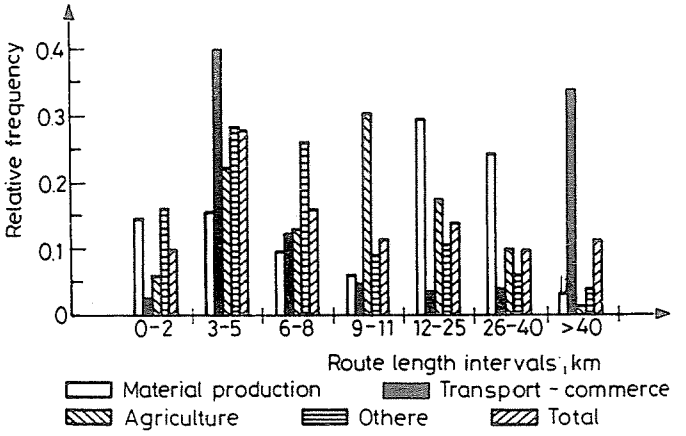

Fig. 4.

Table 6
Empirical distribution of delivery vans route length between 5 am and 5 pm

Branch	Relative frequency of random variable realization for route length intervals in km							
	0–2	3–5	6–8	9–11	12–25	26–40	>40	amount
1	0.170	0.182	0.086	0.076	0.253	0.202	0.031	1969
2	0.024	0.479	0.122	0.044	0.031	0.028	0.272	2855
3	0.057	0.201	0.119	0.360	0.177	0.061	0.025	5520
4	0.150	0.293	0.277	0.095	0.091	0.060	0.034	1808
Total	0.081	0.277	0.138	0.200	0.142	0.076	0.086	12152

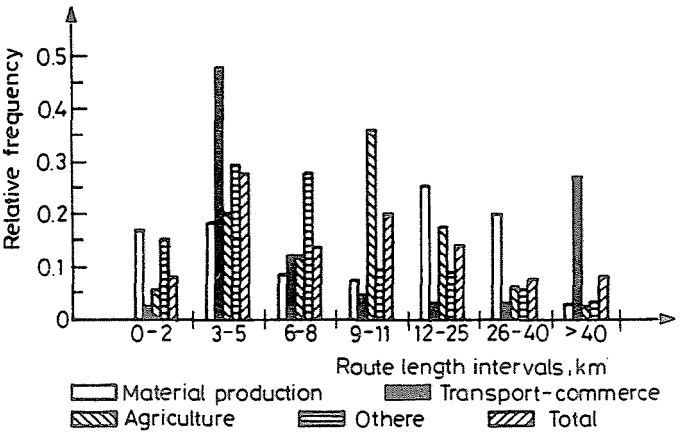

Fig. 5.

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