

MIRSAD KULOVIĆ, D. Sc.  
Tennessee Department of Transportation  
Nashville, TN 37243, USA  
Mirsad.Kulovic@state.tn.us

Technology and Management of Traffic

Review

U. D. C.: 656.135:65.012:656.03

Accepted: May 6, 2004

Approved: Oct. 27, 2004

## FREIGHT TRANSPORT COSTS MODEL BASED ON TRUCK FLEET OPERATIONAL PARAMETERS

### ABSTRACT

*The road freight transport costs are a function of numerous factors that could be grouped according to their characteristics and level of utilization of company's technical and human potential. The different input prices, product characteristics, truck configuration, geographical characteristics, road conditions, and driving characteristics make it very difficult to estimate the current transportation costs for a particular company. To investigate the main factors that may affect road freight transport costs, it is useful to analyze the influence of truck fleet operational parameters on these costs. This paper describes freight transport costs model based on truck fleet operational parameters. The explanation of the model is given through a practical example. The model enables changes of input parameters and reflects the influence of different management decisions which have an impact on transportation costs.*

### KEY WORDS

*model, transport, freight, costs, fleet, truck*

### 1. INTRODUCTION

The road freight transport costs are a function of numerous factors that could be grouped into factors which are or which are not in the domain of trucking company influence. The factors which are not in the domain of trucking company influence are constant parameters for transport costs calculation and they are the result of certain market and other conditions (fuel and spare price, insurance, vehicle registration fee etc.). The factors on which the trucking companies have an influence are associated with quality and quantity of company's activities. These factors depend on the utilization of the company's technical and human potential. The influence of these factors may be expressed by operational parameters of truck fleet utilization such as coefficient of fleet utilization, average speed, coefficient of available time utilization, average distance of loaded truck run, etc.

The trucking companies face different input prices, product characteristics, truck configuration, geographical characteristics, firm size and driving

characteristics. Thus, obtaining current estimates of costs for a particular company is very difficult. To investigate the main factors that may affect truck transport costs it is useful to examine the influence of truck fleet operational parameters on transport costs. This paper describes freight transport costs model based on truck fleet operational parameters. The explanation of the model is given through a practical example. The model enables changes of input parameters and reflects the influence of different management decisions which have an impact on the transport costs.

### 2. FACTORS AFFECTING COSTS OF TRUCKING OPERATIONS

The main factors that affect costs of trucking operations are:

- Truck size and its utilization;
- Back-haul possibilities (demand pattern);
- Empty running;
- Availability of freight forwarding and other services;
- Road and traffic conditions;
- Input of factor prices (labor, vehicle, spares and fuel);
- Quality of management.

**Table 1 - The typical proportion of truck transportation costs**

	Cost Item	Proportion of Operating Costs [%]
Variable Costs	Fuel	20-30
	Lubrication Oil	1-5
	Tires	10-15
	Spares	15-20
Fixed Costs	Drivers	10-20
	Other Labor	5
	Depreciation and Interest	15-20
	Overheads and Other	10-15



While cost is usually the single most important aspect of trucking services, customers also require fast, secure and reliable door-to-door delivery of goods. The vehicle utilization (vehicle-km per year) significantly affects the balance between fixed and variable costs. The typical proportion of transport costs for efficient trucking operations (in low and medium income countries and medium vehicle utilization) is given in Table 1.<sup>1</sup>

Higher than expected proportion of fixed costs could indicate vehicle utilization much less than 100 000 km per truck. The low utilization is often caused by the following factors:

- Poor condition of roads due to inadequate maintenance;
- Poor conditions of vehicles due to absolute trucks, inadequate maintenance and poor driving methods;
- Inadequate management and operational practices.

### 3. MODEL DESCRIPTION AND APPLICATION

To investigate the main factors that may affect freight transport costs it is useful to examine the influence of trucks fleet operational parameters on the transport costs.

The transport costs per unit of transportation work (ton-kilometer- tkm) can be expressed as<sup>2</sup>:

$$C_t = X[YC_f(Z + \varphi) + ZC_v] \quad \$/tkm \quad (1)$$

where:

- $C_t$  – total transport costs;
- $C_f$  – fixed transport costs;
- $C_v$  – variable transport costs;
- $X$  – factor which expresses the influence of vehicle capacity and its utilization;

$$X = \frac{1}{\varepsilon q} \quad (2)$$

- $\varepsilon$  – coefficient of vehicle capacity utilization<sup>3</sup>;
- $q$  – vehicle capacity;
- $Y$  – factor which expresses the influence of available fleet and time utilization;

$$Y = \frac{1}{\alpha \rho} \quad (3)$$

- $\alpha$  – coefficient of vehicle fleet utilization (Proportion of days when the vehicle is available for work and total available days in a certain period);
- $\rho$  – coefficient of time utilization (proportion of hours of operation and 24 hours);
- $Z$  – factor which expresses the influence of path (route) utilization and speed;

$$Z = \frac{1}{\beta S} \quad (4)$$

- $\beta$  – coefficient of path utilization (proportion of kilometers of empty running and the total number of kilometers);

$S$  – average speed;

$F$  – factor which expresses the influence of lost time and distance of transport with load;

$$F = \frac{T_l}{L_t} \quad (5)$$

$T_l$  – lost time;

$L_t$  – distance of transport (average length of loaded truck run);

The equation (1) enables simultaneous detail analysis of transport costs as a function of truck fleet operational parameters and characteristics group of similar operational parameters. Thus, the value  $X$  represents the influence of elements which are related to the average carrying capacity of truck fleet and utilization of that capacity. The value  $Y$  is in direct relation to the truck fleet utilization (proportion of time when it is available for work rather than under repair) and utilization of available time (proportion of time in operation during 24 hours). This factor directly reflects the quality of the company's management activities. The value  $Z$  represents the influence of elements related to path (route) utilization (proportion of loaded and unloaded distance traveled) and average speed. Thus, this factor expresses the influence of back-haul possibilities, demand patterns, availability of freight forwarding, road, traffic, and vehicle conditions. The value  $F$  represents the proportion of the average lost time and the average distance on which freight is carried. This factor, to some degree, expresses the quality of trucking company's management and to a large degree it expresses the quality of consignor's and consignee's loading and unloading activities. In order to illustrate the model application we have used the aver-

Table 2 Truck fleet operational parameters

Parameter	Value
Coefficient of fleet utilization ( $\alpha$ )	0.61
Coefficient of time utilization ( $\rho$ )	0.56
Coefficient of path utilization ( $\beta$ )	0.68
Coefficient of vehicle capacity utilization ( $\varepsilon$ )	0.72
Average vehicle capacity - $q$ (ton)	14.00
Average speed - $S$ (km per hour)	35.00
Average lost time - $T_l$ (hour)	6.00
Average distance of transport - $L_t$ (km)	140.00
Fixed costs - $C_f$ (\$ per hour)	1.27
Variable costs - $C_v$ (\$ per hour)	2.79



age values of operational parameters for truck fleet sample which consists of 7,472 trucks. <sup>1</sup> These data are presented in Table 2.

Using the data from Table 2 and applying the equation (1) we obtain the truck transport costs:

$$C_t = X[YC_f(Z+F)+ZC_v] = 0.099 \times [2.94 \times 1.27(0.042+0.043)+0.042 \times 2.79] = 0.025 \times 1.27 + 0.004 \times 2.79 = 0.032 + 0.011 = \$0.043 \text{ per tkm}$$

where:

$$X = \frac{1}{\epsilon q} = \frac{1}{0.72 \times 14.00} = \frac{1}{10.08} = 0.099$$

$\epsilon$  – coefficient of vehicle capacity utilization;

$q$  – average vehicle capacity;

$$Y = \frac{1}{\alpha \rho} = \frac{1}{0.61 \times 0.56} = \frac{1}{0.34} = 2.94$$

$\alpha$  – coefficient of vehicle fleet utilization (proportion of days when the vehicle is available for work and total available days in certain period);

$\rho$  – coefficient of time utilization (proportion of hours of operation and 24 hours);

$$Z = \frac{1}{\beta S} = \frac{1}{0.68 \times 35} = \frac{1}{23.8} = 0.042$$

$\beta$  – coefficient of path utilization (proportion of kilometers of empty running and the total number of kilometers);

$S$  – average speed;

$F$  – factor which expresses the influence of lost time and distance of transport;

$$F = \frac{T_l}{L_t} = \frac{6.0}{140} = 0.043$$

$T_l$  – lost time;

$L_t$  – distance of transport (average length of run of loaded truck);

Values of each factor are calculated for a different combination of operational parameters. For the illustration purposes the results for factor Z are given in Table 3. The relationship of each factor and the corresponding truck fleet operational parameters is shown in Figure 1.

Figure 2 shows the relationship between transport costs and truck fleet operational parameters. This relationship is based on the X, Y, Z and F-factor values as a function of truck fleet operational parameters and equations (1) – (5). An analysis of the diagram shown in Figure 2 gives us the opportunity to obtain the transport costs changes depending on the changes of certain operational parameters. Thus, for example, if the coefficient of path (route) utilization increases from 0.6 to 0.7 the transportation costs will decrease by 10% or \$0.0046 per ton-km. For medium level truck utilization of 60,000 km per year and 14 tons of truck capacity, it will save \$2,705 per year per truck. Factor F has the greatest influence on the transportation costs – proportion of lost time and average distance of the loaded truck traveled. For constant distance of the loaded truck travel lost time has decisive influence on the transport costs. Thus, in the previous example, if the lost time increases by 2 hours on 140 km loaded truck transport distance the transport costs will increase \$2,940 per year per truck.

#### 4. CONCLUSION

The truck fleet operational parameters have decisive influence on transport costs per ton-kilometer. The greatest influence on these costs involves the loss of time which includes: waiting time, travel time from depot to loading spot and time needed for loading and unloading operations. The road freight transport costs model which is presented in this paper is based on truck fleet operational parameters. These parameters are different coefficients which represent the level of

Table 3 - Values of factor Z as function of  $\beta$  and S

$\beta / S$	0.50	0.55	0.60	0.65	0.70	0.75	0.80	0.85	0.90	0.95	1.00
10.00	0.200	0.182	0.167	0.154	0.143	0.133	0.125	0.118	0.111	0.105	0.100
15.00	0.133	0.121	0.111	0.103	0.095	0.089	0.083	0.078	0.074	0.070	0.067
20.00	0.100	0.091	0.083	0.077	0.071	0.067	0.063	0.059	0.056	0.053	0.050
25.00	0.080	0.073	0.067	0.062	0.057	0.053	0.050	0.047	0.044	0.042	0.040
30.00	0.067	0.061	0.056	0.051	0.048	0.044	0.042	0.039	0.037	0.035	0.033
35.00	0.057	0.052	0.048	0.044	0.041	0.038	0.036	0.034	0.032	0.030	0.029
40.00	0.050	0.045	0.042	0.038	0.036	0.033	0.031	0.029	0.028	0.026	0.025
45.00	0.044	0.040	0.037	0.034	0.032	0.030	0.028	0.026	0.025	0.023	0.022
50.00	0.040	0.036	0.033	0.031	0.029	0.027	0.025	0.024	0.022	0.021	0.020
55.00	0.036	0.033	0.030	0.028	0.026	0.024	0.023	0.021	0.020	0.019	0.018
60.00	0.033	0.030	0.028	0.026	0.024	0.022	0.021	0.020	0.019	0.018	0.017



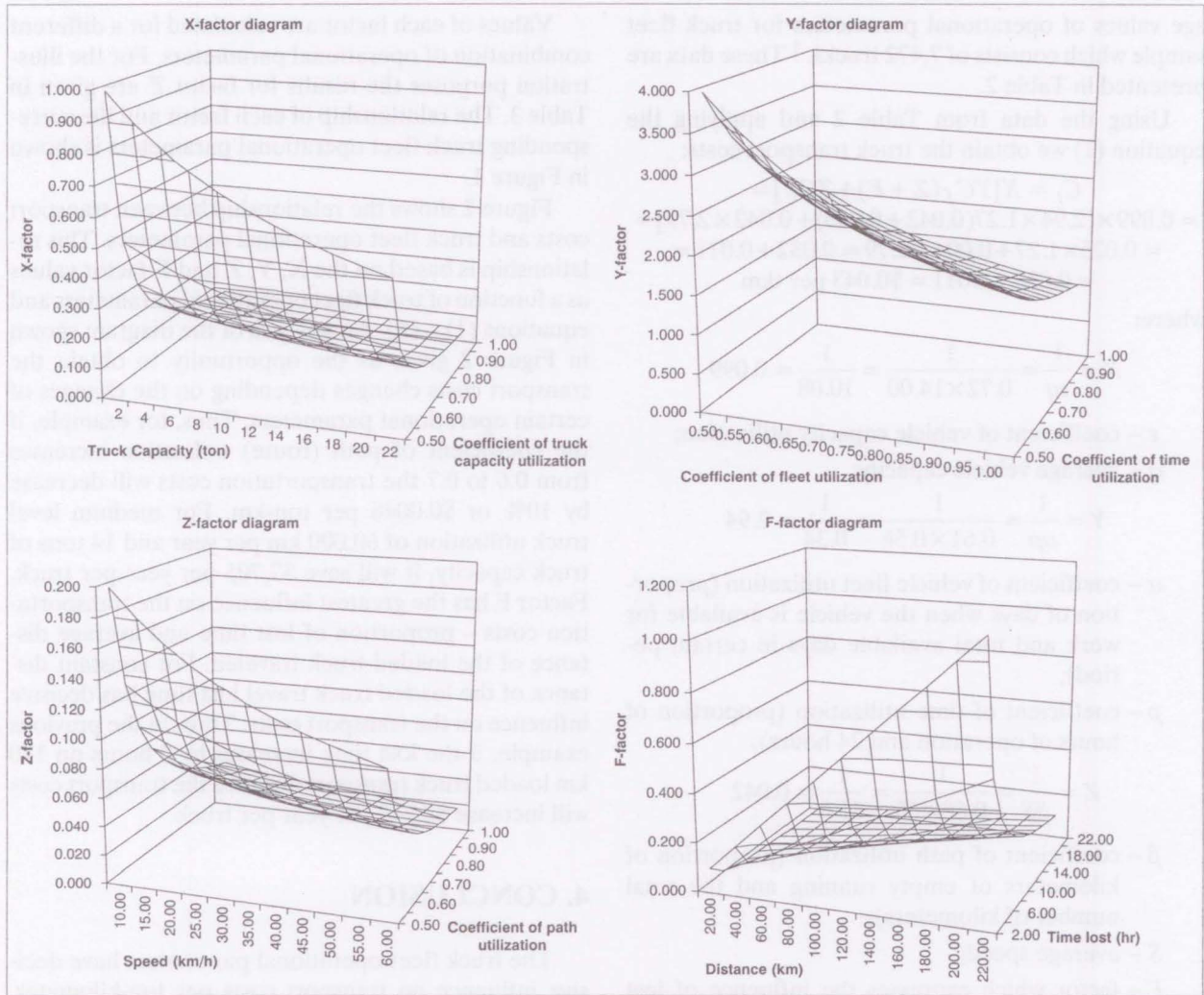


Figure 1 - Relationship between X, Y, Z and F factors and the corresponding truck fleet operational parameters

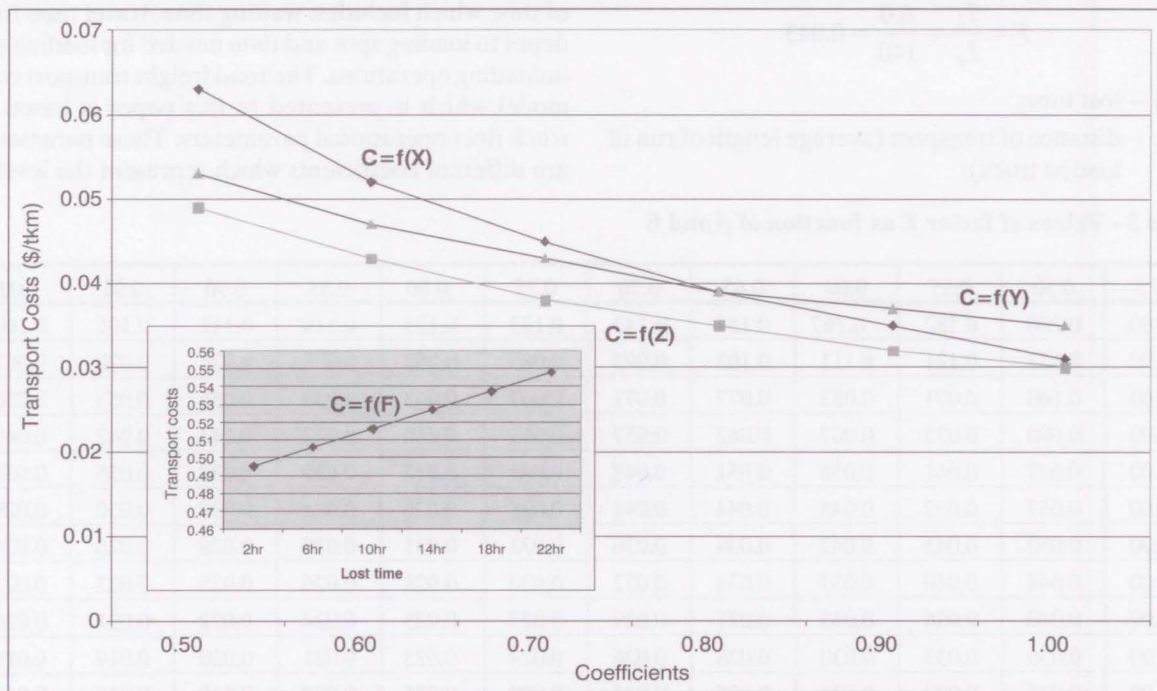


Figure 2 - Transport costs and truck fleet operational parameters relationship

utilization of fleet, time, truck capacity and path (route), average speed and distance of loaded truck traveled. This model enables detailed, relatively easy analysis and influence of different operational conditions on transportation costs. The model also enables changes of input parameters and reflects influence of different organizational activities and management decisions on transport costs. An example of this model shows the possibility of its practical usage.

MIRSAD KULOVIĆ, D. Sc.  
Tennessee Department of Transportation  
Nashville, TN 37243, USA  
Mirsad.Kulovic@state.tn.us

#### **MODEL TROŠKOVA TRANSPORTA TERETA BAZIRAN NA OPERATIVNIM PARAMETRIMA VOZNIH PARKOVA TERETNIH VOZILA**

*Troškovi cestovnog transporta tereta su funkcija mnogobrojnih faktora koji mogu biti grupirani shodno njihovim karakteristikama i nivou iskorištenosti tehničkih i ljudskih potencijala kompanije. Različite ulazne cijene, karakteristike proizvoda, vrste teretnih vozila, geografske karakteristike, cestovni uvjeti i vozačke karakteristike čine veoma složenim procjenu aktualnih transportnih troškova za određenu kompaniju. Da bi se istražili glavni faktori koji mogu utjecati na troškove transporta tereta korisno je analizirati utjecaj operativnih parametara vozni parkova na ove troškove. Ovaj rad opisuje model troškova transporta tereta baziranog na operativnim parametrima vozni parkova teretnih vozila. Objašnjenje modela je*

*dano kroz praktičan primjer. Model omogućava promjene ulaznih parametara i odražava utjecaj različitih upravljačkih odluka koje utječu na transportne troškove.*

#### **KLJUČNE RIJEČI**

*model, transport, teret, troškovi, vozni park, teretno vozilo*

#### **REFERENCES**

1. Kulovic, M., and Dobric, M., "A contribution to the study of road motor vehicle fleet operational indexes" *Suvremeni promet*, Vol. 8, No. 6 pp. 497-502, Zagreb, Croatia, 1986
2. Vivian, S., and Leorey, M., *An Intelligent Assistant For Fleet Management Using Microsoft Excel*, 23<sup>rd</sup> Conference of Australian Institutes of Transport Research, Institute of Transport Studies Monash University, Melbourne, 2001

#### **LITERATURE**

- [1] *Measuring Road Transport Performance*, [www.worldbank.org/html/fpd/transport](http://www.worldbank.org/html/fpd/transport)
- [2] Kulovic, M., "Optimization of the size, structure and techno-operational indexes of truck fleet in road freight transport", Doctoral dissertation, Faculty of Traffic, University of Sarajevo, Bosnia and Herzegovina, pp. 48-70, 1989.
- [3] Topenčarević, Lj., "Organizacija i tehnologija drumskog transporta" IRO Gradjevinska knjiga, Beograd, Yugoslavia, 1987