Journal of KONES Powertrain and Transport, Vol. 22, No. 2 2015

ISSN: 1231-4005
e-ISSN: 2354-0133
DOI: 10.5604/12314005.1165451

TRANSPORT SERVICE EXECUTION COSTS IN THE WHOLE-VEHICLE ROAD TRANSPORT IN COMPLEX TRANSPORT CYCLES

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Abstract

Companies compete not only on price of offered products and services, but also on the quality, including the time of delivery of the product or service implementation. Contemporary logistics solutions, ensuring high utilization mileage of means of transport, cause, that in transport complex transport cycles are increasingly common. In these cycles as opposed to a simple transport, cycles are realized many transport tasks. The paper presents the classification of the costs of implementing of transport processes in road transport. Taking into account the different cost sharing criteria was proposed their general classification. Were identified means of transport parameters that have the most significant impact on the level of costs in transport. Then, assuming that in one transport cycle can be realized many transport tasks were presented analytical dependences on the implementation costs of transport cycles, as well as the implementation costs of individual transport tasks. Presented in the article approach can be used to calculate costs of implementing full truck transport tasks performed both in complex and simple (special case) cycles.

Types of costs in road transport, general classification of costs in the road transport, vehicle parameters affecting the level of direct costs of transport, principles for determining the cost of road transport carriage are presented in the paper.

Keywords: *road transport costs, allocation cost tasks, road transport*

1. Introduction

In an era of strong competition, the market success of the company is conditioned by high flexibility in responding to customers' high requirements regarding the quality of the services provided. Companies compete not only on price of offered products and services, but also on the quality, including the time of delivery of the product or service implementation. High hopes in improving the quality (e.g. in terms of product availability and timeliness of delivery) is put in logistics, which forms the connections and relationships, and controls the flow of goods between suppliers and customers [5]. Contemporary logistics solutions, ensuring high utilization mileage of means of transport, cause, that in transport complex transport cycles are increasingly common. In these cycles as opposed to a simple transport, cycles are realized many transport tasks. This makes the costs of transport cycle’s realization must be properly distributed to individual transport tasks.

Moreover, one of the conditions for the effective functioning of every transport company is to reduce costs. In the era of market economy, especially road transport industry should reduce costs for the proper functioning of the company. Companies can reduce costs only if they know the cause of their formation and can correctly assigned them to each action. For this purpose, it is necessary detailed analysis of the components of costs especially with the division into fixed and variable costs. The essence of this analysis is to identify factors that have influenced the individual cost elements. This analysis is the appropriate basis for the identification of the costs of the implementation of individual transport tasks.

2. Types of costs in road transport

Total costs of transport company are the sum of expenditures on their service business, expressed in the form of cash and billed at a certain time. Therefore, these costs include components of fixed assets and current assets, the workload, as well as other expenses (taxes, interest, fees, rents etc.) justified from the point of view transport business activity. This means that the total cost of the company are composed of various elements with different characteristics. For this reason, it is performed the classification costs i.e. their systematic, extensive division into the individual components according to established criteria (rules), and then combining these components in appropriate groups (or classes) [3].

Costs incurred by the company to achieve sales of products or services, in accordance to the Accounting Act [10], are treated as expenses of operating activities. In addition, are isolated other operating costs and financial costs, which in the article were omitted. Expenses of operating activities are classified usually due to the following criteria [2, 3]:

- types and kinds of activities,
- the complexity of costs,
- type of costs,
- the degree of costs variability,
- places where costs rise up,
- the relationship of costs with the environment.

In the publications relating to road transport is mostly used the division of costs for indirect costs and direct costs, fixed and variable. Thus, at the same time the criterion of cost and their changeability is used (Fig. 1).

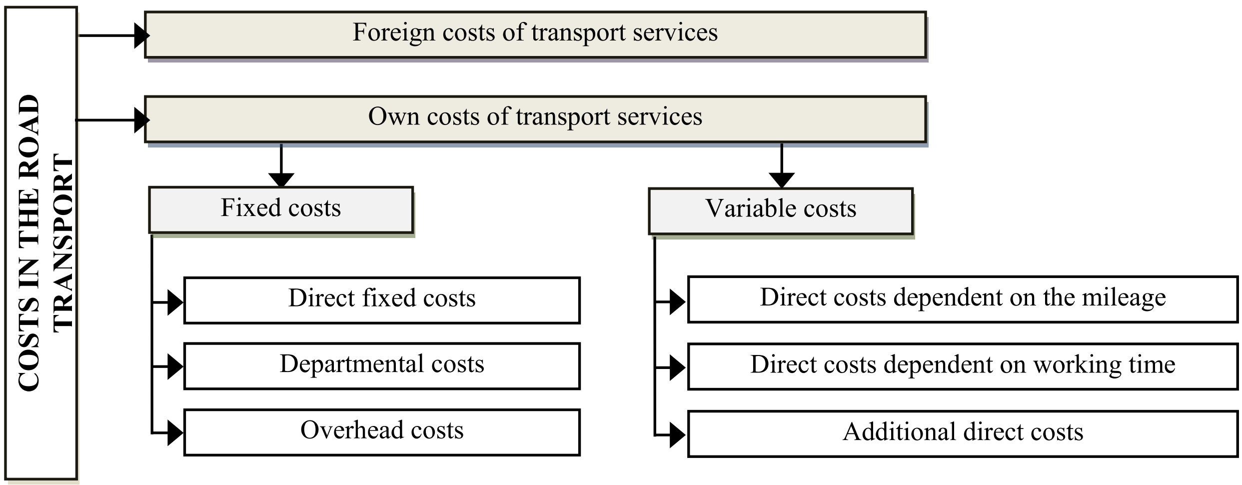

Fig. 1. General classification of costs in the road transport [6]

Included in Fig. 1 overhead costs apply to the entire company and its management. Therefore, they include inter alia amortization of real estate and other fixed assets, property maintenance costs and energy consumption, property tax, fees for perpetual usufruct of land and training, research and salaries of managers. Assuming that in the company can be distinguished certain departments engaged in particular activity, should be considered separately the costs specific to these departments, i.e. departmental costs.

In view of these overhead costs can be offset on transport tasks taking into account the surcharge on the direct cost (proportionally to the revenue from different areas of divisions of the company). However, the departmental costs can be offset into transport tasks, taking into account the working time of vehicles or e.g. their loaded course.

What are important in road transport among the variable costs can be distinguished costs dependent on vehicle mileage, of working time, as well as additional variable costs that result from the specific character of the transport task and cannot be directly related to the units of mileage or working time. However, among the fixed costs is taken into account, among others, depreciation of fixed assets and the cost of capital freezing or other costs incurred once every few years, including the costs of periodic training and testing of drivers.

3. Vehicle parameters affecting the level of direct costs of transport

For the purpose of writing the formalization of transport costs it is assumed that the s indicates the number of the vehicle or combination of vehicles, and a set of numbers means of transport of road transport (vehicles and combinations of vehicles) has the form: $\boldsymbol{S} = \{1, \ldots, s, \ldots, S\}$.

Among the most important characteristics of the means of transport are primarily its type and its degree of adaptation to the carriage of the cargo specified by the vehicle use and design features of the body. It is assumed that the vehicle characteristics determine its type indicated later in with the symbol $t(s)$. In this perspective, the type of vehicle directly determines its applicability to the implementation of individual transport tasks.

It is easy to show that the execution costs of the transport tasks stem mainly from the size of this task (volume of cargo) and characteristics of loading units (dimensions, spatiality), as well as transport capacity of used vehicles, i.e. with their payload $q(s)$ and capacity $v(s)$ or the number of seats $ms(s)$ and total seats $mo(s)$. The capacity of the vehicle is better suited to the transport task the unit cost of transport is lower.

To direct fixed costs of transport significantly affects the value of the vehicle along with its possibly additional equipment $W_P(s)$, because of it depends on the cost of vehicle consumption, or the cost of its insurance. In addition, it is important here the expected lifetime of the vehicle $N^E(s)$ and its final value after that period $W_K(s)$. In contrast, vehicle parameters significantly affecting the level of costs of their exploitation is primarily the type of fuel used to their propulsion $p(s)$, unit fuel consumption as a function of vehicle load $zp(s, m(s))$[1], fuel tank capacity $pz(s)$, performed by vehicle exhaust emission standard $e(s)$, number of wheels $lk(s)$, the type of tires $ro(s)$ and the permissible gross vehicle weight $dm(s)$. Moreover, due to fixed costs is relevant the number of axles of the vehicle $no(s)$ and type of suspension $rz(s)$, or the vehicle age $y(s)$ and its total mileage $l(s)$.

Considering the above as the most important characteristics of vehicles that have an impact on the level of direct transport costs were distinguished their:

- type $t(s)$,
- capacity $q(s)$,
- capacity cargo space $v(s)$,
- number of seats $ms(s)$,
- number of total seats $mo(s)$,
- the value along with its possibly additional equipment $W_P(s)$,
- durability, i.e. expected lifetime $N^E(s)$,
- final value after the period of exploitation $W_K(s)$,
- fuel used to the propulsion $p(s)$,
- unit fuel consumption as a function of vehicle load $zp(s, m(s))$[3],
- fuel tank capacity $pz(s)$,
- number of wheels $lk(s)$,
- type of tires $ro(s)$,

[1] The symbol $m(s)$ is the average weight of cargo carried in one transport cycle implemented by the s-th vehicle. In the real operating conditions of vehicles unit fuel consumption is also dependent on the traffic conditions of the vehicle.

- performed exhaust emission standard $e(s)$,
- permissible gross weight $dm(s)$,
- number of axles $no(s)$,
- type of suspension $rz(s)$,
- age $y(s)$,
- total mileage $l(s)$.

4. Principles for determining the cost of road transport carriage

According to the introduction, individual transport tasks are carried out in the appropriate cycles of transport. Of course, there is latitude in terms of design of transport cycles, as well as to dispose of their handling individual means of transport. It is assumed that z represents the number of the transport task, and a set of numbers transport tasks, which carries the company, has the form: $\boldsymbol{Z} = \{1, \ldots, z, \ldots, Z\}$. Number of the transport cycle was indicated with c, and a set of numbers of those cycles has the form: $\boldsymbol{C} = \{1, \ldots, c, \ldots, C\}$. Then the set of numbers of transport tasks performed in the c-th transport cycle was indicated as $\boldsymbol{Z}(c)$, and the number of mean of transport assigned to operate c-th cycle was indicated as $s(c)$.

For allowable assignment, transport tasks to transport cycles and means of transport to cycles the following relationships are fulfilled:

$$\bigcup_{c \in \boldsymbol{C}} \boldsymbol{Z}(c) = \boldsymbol{Z} \quad \wedge \quad \forall_{c, c' \in \boldsymbol{C}} \quad \boldsymbol{Z}(c) \cap \boldsymbol{Z}(c') = \varnothing, \tag{1}$$

$$\forall_{c \in \boldsymbol{C}} \quad s(c) \in \boldsymbol{S}. \tag{2}$$

To direct fixed costs include mainly (see e.g. [6]):

- the cost of vehicle use,
- the cost of vehicle financing (leasing and capital)
- the cost of periodic technical inspection of vehicles,
- the cost of vehicle insurance,
- the cost of taxes on means of transport,
- periodical duties for using roads − currently in Poland there are do not exist[2],
- the cost of drivers labour,
- the cost of raining and testing the drivers.

In contrast to direct variable costs include (see e.g. [6]):

- direct variable cost depending on the mileage including:
  - cost of consumption of engine fuels,
  - cost of tire use,
  - costs of technical maintenance and repairs and cleaning vehicles
  - environmental charges;
- direct variable cost dependent on the working time:
  - the components of remuneration,
  - rents for equipment;
- additional direct variable cost (due to the traffic nature):
  - delegations of drivers (diet, accommodation costs),
  - additions to salaries (for on-call time, for night work and overtime hours),
  - one-time charges for the use of transport infrastructure (roads, tunnels, ferry service),

[2] In Poland, periodic charges for use of national roads have been abolished as from 1 July 2011 for the benefit of one-time charges for the use of selected sections of the national road network. In the last period of validity, periodic charges they were conditioned (outside the period of validity) by the type of vehicle, its GVW and performed by the vehicle exhaust emission standard.

– cargo insurance,
– cargo convoying,
– charges for transport approval.

Counting the cost of vehicle use as part of the cost of the implementation of the transport cycle should take into account the so-called wear-carrying amount of amortization of vehicles, which results from the Accounting Act. [10]. Inclusion here amortization calculated in accordance with tax law is often a mistake made. Taking into account that in accordance with accounting regulations of the vehicle value $W_P(s)$ decomposes into its useful life of exploitation and is taken into account the residual value of vehicle $W_K(s)$ after the period of its exploitation in a given company $N^E(s)$, the cost of vehicle use was written as the dependence related to the implementation of the transport cycle:

$$K_A^C(c) = t_{PP}^C(c) \cdot \frac{W_P(s(c)) - W_K(s(c))}{N^E(s(c)) \cdot t_{PP}^R(s(c))} \quad \text{(PLN)}, \tag{3}$$

where:

$K_A^C(c)$ – the cost vehicle use during the implementation of c-th transport cycle in PLN,
$t_{PP}^C(c)$ – time of implementation c-th transport cycle in days,
$W_P(s(c))$ – initial value of $s(c)$-th vehicle implementing c-th transport cycle in PLN,
$W_K(s(c))$ – the residual value of $s(c)$-th vehicle implementing c-th transport cycle in PLN,
$N^E(s(c))$ – the expected number of years of exploitation of $s(c)$-th vehicle implementing c-th transport cycle,
$t_{PP}^R(s(c))$ – annual operating time $s(c)$-th vehicle implementing c-th transport cycle in days/year.

Vehicle financing costs are dependent on the method of financing their purchase and may include, for example. lease payments (for operating leases) or freezing cost of capital (for the purchase of vehicles from own resources). In both cases level of these costs is directly related to the value of the vehicle and the cost of capital (foreign or its own). In addition for vehicle financing from own resources must be taken into account here the effect of withdrawal of frozen assets through depreciation charges – which is usually overlooked. Therefore, these costs also result from the adopted method of depreciation. As a result, the vehicle financing costs result from its initial value $W_P(s)$ and accepted method of financing.

Considering the above vehicle financing costs from own resources in case of their linear depreciation method and monthly depreciation charges was expressed in the relationship:

$$\begin{aligned} K_F^C(c) = t_{PP}^C(c) \cdot \frac{W_P(s(c)) \cdot \alpha_K}{12 \cdot N^E(s(c)) \cdot t_{PP}^R(s(c))} \cdot \min\left\{ \left\lceil \frac{12}{\alpha_A(s(c))} \right\rceil ; N^E(s(c)) \cdot 12 \right\} \cdot \\ \cdot \left(1 - \min\left\{ \left\lceil \frac{12}{\alpha_A(s(c))} \right\rceil - 1 ; N^E(s(c)) \cdot 12 - 1 \right\} \cdot \frac{\alpha_A(s(c))}{2 \cdot 12} \right) \quad \text{(PLN)}, \end{aligned} \tag{4}$$

where:

$K_F^C(c)$ – cost of capital freezing invested in the purchase of a vehicle attributable to the c-th transport cycle in PLN,
α_K – the annual cost of capital freezing in %/year,
$\alpha_A(s(c))$ – annual depreciation rate of $s(c)$-th vehicle implementing c-th transport cycle in %/year, other designations as in formula (3).

Other direct fixed costs associated with the operation of vehicles, i.e. the cost of periodic technical inspection of vehicles, vehicle insurance costs and the cost of taxes on means of transport are included together. The height of the first two of these costs is dependent on the type of vehicle

$t(s)$ and its age $y(s)$ and total mileage $l(s)$ – these parameters are taken into account when determining insurance premiums, and they determine the type and cost of periodic technical inspections. By contrast, the cost of taxes on means of transport in accordance with Art. 10 of the Act on Local Taxes and Fees [9] may depend on the type of vehicle, its permissible total weight, number of axles, type of suspension, the impact on the environment, year of production and the number of seats[3]. However, in individual municipalities there are significant differences in the classification of vehicles and the rates of tax. Municipalities often omit available criteria for the classification of vehicles or use them in very limited extent (i.e. here are used two criteria: EURO 2 standard and higher and the EURO 1 standard and lower). Generally it can be assumed that taxes on means of transport result from vehicle type $t(s)$, the number of its axles $no(s)$ and the type of suspension $rz(s)$ and its permissible total weight $dm(s)$ or number of seats $ms(s)$, or performed by the vehicle exhaust emission standards $e(s)$ – these characteristics of vehicles have an impact on the tax rate for a given mean of transport.

Considering the above, attributable to the transport cycle other direct fixed costs associated with the operation of vehicles formally were written as follows:

$$K_{PI}^{C}(c) = \frac{t_{PP}^{C}(c)}{t_{PP}^{R}(s(c))} \cdot (K_{B}^{R}(s(c)) + K_{U}^{R}(s(c)) + K_{PP}^{R}(s(c))) \quad \text{(PLN)}, \tag{5}$$

where:

$K_{PI}^{C}(c)$ – other direct fixed costs associated with the operation of vehicles attributable to c-th transport cycle in PLN,

$K_{B}^{R}(s(c))$ – the cost of periodic technical inspections of $s(c)$-th vehicle implementing c-th transport cycle in PLN/ year,

$K_{U}^{R}(s(c))$ – automobile insurance of the vehicle $s(c)$ implementing c-th transport cycle in PLN/year,

$K_{PP}^{R}(s(c))$ – tax on means of transport for $s(c)$-th vehicle implementing c-th transport cycle in PLN/year,

other designations as in formula (3).

For the cost of driver, working employed under an employment relationship consists of its gross salary (*WB*) and insurance premiums, and other paid by the employer[4]. These premiums include pension insurance *Uep* (9.76% *WB*), disability insurance *Urp* (6.50% *WB*), accident insurance *Uw* (1.20% *WB*), premium for the Labour Fund *Sp* (2.45% *WB*) and premiums for the Guaranteed Employee Benefits Fund *Sś* (0.10% *WB*). Consequently, in accordance with the current (June 2015) provisions, drivers labour cost employed under an employment relationship are equal to 120.01% of his gross salary[5]. An important aspect of cost accounting of employee's full-time work is to include their right to holidays and to their sickness absence. As a result, dependence mapping fixed costs of drivers labour attributable to the transport cycle is as follows:

$$K_{K}^{C}(c) = \sum_{k \in \boldsymbol{K}(c)} \frac{t_{PK}^{C}(c,k) \cdot K_{K}^{M}(k)}{t_{PK}^{M}(k) \cdot \alpha_{UK}(k) \cdot \alpha_{ZK}(k)} \quad \text{(PLN)}, \tag{6}$$

where:

$K_{K}^{C}(c)$ – fixed costs of drivers labour attributable to the c-th transport cycle in PLN,

$t_{PK}^{C}(c,k)$ – labour time of k-th driver in c-th transport cycle in h,

[3] The last three criteria may be used only for vehicles with a GVW of less than 12 tonnes and for buses.

[4] [11], Art. 16, paragraphs 1, 1b, 2 i 3; Art. 22, paragraphs 1 and 2 and other provisions.

[5] For a group of business „Land transport and transport via pipelines", at risk category equal to 4 and individual correcting indicator depending on risk category 1,0 and number of insured reported by a payer more than 9.

$K_K^M(k)$ – monthly labour costs of k-th driver in PLN/month,
$t_{PK}^M(k)$ – monthly work time of k-th driver in PLN/month,
$\alpha_{UK}(k)$ – participation of days present of k-th driver on holiday on his work days in total in %,
$\alpha_{ZK}(k)$ – participation of days present of k-th driver on layoffs on his work days in total in %,
$\boldsymbol{K}(c)$ – set of numbers of drivers implementing c-th transport cycle.

Professional drivers are subject to various trainings and researches related to obtaining permission to drive vehicles in the various categories, and with obtaining the right to practice the profession of driver. Overall, the number of periodic training or testing of driver was designated with the symbol i, while dependence mapping the costs of training and testing of drivers attributable to the cycle transport was written as follows::

$$K_S^C(c) = \sum_{k \in \boldsymbol{K}(c)} \frac{t_{PK}^C(c,k)}{t_{PK}^M(k) \cdot \alpha_{UK}(k) \cdot \alpha_{ZK}(k)} \cdot \sum_{i \in \boldsymbol{I}(k)} \frac{K_{SK}^O(k,i)}{T_{SK}^O(k,i)} \quad \text{(PLN)}, \qquad (7)$$

where:
$K_S^C(c)$ – fixed costs of drivers trainings and researches attributable on c-th transport cycle in PLN,
$K_{SK}^O(k,i)$ – costs of i-th training or research of k-th driver in PLN,
$T_{SK}^O(k,i)$ – period of validity of i-th training or research of k-th driver in months,
$\boldsymbol{I}(k)$ – set of numbers of trainings and researches, which is subject to k-th driver,
other designations as in formula (6).

The cost engine fuels consumption is a function of the type of fuel used $p(s)$, unit fuel consumption function $zp(s, m(s))$ and the capacity of the fuel tank $pz(s)$, which determines the strategy of long-distance transport refuelling[6]. Taking into account the different levels of fuel consumption during the implementation of the transport cycle associated with various vehicle load, the cost engine fuels consumption in the transport cycle formally was written as follows:

$$K_P^C(c) = \frac{cp(s(c))}{100} \left(\sum_{z \in \boldsymbol{Z}(c)} zp(s(c), m(z)) \cdot Lp(c,z) + zp(s(c),0) \cdot Lp(c,0) \right) \quad \text{(PLN)}, \qquad (8)$$

where:
$K_P^C(c)$ – the cost engine fuels consumption in c-th transport cycle in PLN,
$cp(s(c))$ – dependent on refuelling strategy the average net unit price of fuel used to power $s(c)$-th vehicle implementing c-th transport cycle in PLN/l or in PLN/m^3,
$zp(s(c), m(z))$ – unit fuel consumption by $s(c)$-th vehicle implementing c-th transport cycle in the carriage of cargo weight in $m(z)$ z-th transport task in l/100 km or in m^3/100 km,
$Lp(c,z)$ – distance carriage of cargo for implementing z-th transport task in c-th transport cycle in km,
$zp(s(c),0)$ – Unit fuel consumption of $s(c)$-th vehicle implementing c-th transport cycle during driving without load in l/100 km or in m^3/100 km,
$Lp(c,0)$ – mileage of vehicle without load in c-th transport cycle in km,
$\boldsymbol{Z}(c)$ – set of numbers of transport tasks implementing in c-th transport cycle.

[6] The significance of this problem stems from the significant differences in the price of fuel in individual countries, or parts of them. For example, the difference between the price of diesel fuel in the UK and in Kosovo is up to 60% [4]. Having regard to the approximately 30-40% of cost of fuel consumption in total cost, this gives about 18-24% difference in total costs.

The cost of tire wear is primarily a function of the number of wheels *lk*(*s*) and the type of used tires *ro*(*s*), that has an impact on the level of prices of tires and their durability. Taking into account the diversity of tires mounted on each axis of the transport means (especially important for combinations of vehicles); the cost of tire wear in the transport cycle was formalized as follows:

$$K_O^C(c) = \sum_{o \in \boldsymbol{O}(s(c))} \frac{co(s(c),o) \cdot lk(s(c),o)}{Lo(s(c),o)} \cdot \left(\sum_{z \in \boldsymbol{Z}(c)} Lp(c,z) + Lp(c,0) \right) \quad \text{(PLN)}, \tag{9}$$

where:

$K_O^C(c)$ – the cost of tire wear in *c*-th transport cycle in PLN,

$co(s(c),o)$ – net price, including replacement of tires mounted on the *o*-th axle in the *s*(*c*)-th vehicle implementing *c*-th transport cycle in PLN,

$lk(s(c),o)$ – number of wheels on *o*-th axle *s*(*c*)-th vehicle implementing *c*-th transport cycle in PLN,

$Lo(s(c),o)$ – mileage of *s*(*c*)-th vehicle implementing *c*-th transport cycle between each replacements of tires in *o*-th axle in km,

$\boldsymbol{O}(s(c))$ – set of numbers of axles of *s*(*c*)-th vehicle implementing *c*-th transport cycle,

other designations as in formula (8).

Technical maintenance costs and repair of the vehicle result from its type *t*(*s*) and its current age *y*(*s*) and total mileage *l*(*s*). In contrast, vehicle-cleaning costs result from its type *t*(*s*) and its permissible total weight *dm*(*s*) or number of seats *ms*(*s*) – these parameters determines the unit price of the service. Overall, the number of maintenance, repair, or vehicle washing operations was designated with the symbol *j*, and dependence mapping the costs of these operations attributable to the cycle transport was written as follows:

$$K_N^C(c) = \sum_{j \in \boldsymbol{J}(s(c))} \frac{K_{NM}(s(c)),j)}{L_{NM}(s(c)),j)} \cdot \left(\sum_{z \in \boldsymbol{Z}(c)} Lp(c,z) + Lp(c,0) \right) \quad \text{(PLN)}, \tag{10}$$

where:

$K_N^C(c)$ – variable costs of technical services and repairs and car washing attributable to *c*-th transport cycle in PLN,

$K_{NM}(s(c)),j)$ – cost of *j*-th technical service, repair, or vehicle washing operations attributable to *s*(*c*)-th vehicle implementing *c*-th transport cycle in PLN,

$L_{NM}(s(c)),j)$ – mileage of *s*(*c*)-th vehicle implementing *c*-th transport cycle after *j*-th technical service, repair or vehicle washing operation in km,

$\boldsymbol{J}(s(c))$ – set of numbers of technical services and repairs and vehicle washing operations of *s*(*c*)-th vehicle implementing *c*-th transport cycle,

other designations as in formula (8).

Ecological charges are a function of the type of fuel used *p*(*s*), its unit consumption *zp*(*s*, *m*(*s*)) and performed by the vehicle exhaust emission standard *e*(*s*). In addition, it is important that environmental fees do not requests when their annual amount does not exceed 800 PLN or higher amount set by the Marshal of the voivodship [12]. Taking into account the environmental regulations and accepting the obligation to make those payments, the formula for amount of the ecological fee attributable to the transport cycle has the form:

$$K_E^C(c) = \frac{\rho(s(c)) \cdot S_P(s(c))}{1000 \cdot 100} \cdot \left(\sum_{z \in \boldsymbol{Z}(c)} zp(s(c),m(z)) \cdot Lp(c,z) + zp(s(c),0) \cdot Lp(c,0) \right) \quad \text{(PLN)}, \tag{11}$$

where:

$K_E^C(c)$ – environmental amount of the fee attributable to *c*-th transport cycle in PLN,

$\rho(s(c))$ – density of the fuel burned in the engine of $s(c)$-th vehicle implementing c-th transport cycle in kg/1 or in kg/m^3,

$S_P(s(c))$ – unit rate of the fee for gases released into the environment which arise in the process of fuel combustion in the engine of $s(c)$-th vehicle implementing c-th transport cycle in PLN/Mg,

other designations as in formula (8).

Remuneration components included in direct variable costs dependent on working time result from established for workers employed, e.g. based on contract of mandate, hourly rates of pay. In the case of drivers employed under a contract of employment with a monthly gross salary this type of costs does not occur. Similarly, rentals for equipment may occur or not in relation to the implementation of the transport cycle. To rent equipment may be included for example loading equipment or vehicles (then there will be no fixed costs of vehicle operation). Dependent on working time direct variable cost of implementation of transport cycle was written as follows:

$$K_W^C(c) = \sum_{k \in \boldsymbol{K}(c)} k_{WP}(k) \cdot t_{PK}^C(c,k) + \sum_{u \in \boldsymbol{U}(c)} k_{WU}(u) \cdot t_{PU}^C(c,u) \quad \text{(PLN)}, \tag{12}$$

where:

$K_N^C(c)$ – dependent on working time direct variable cost for c-th transport cycle in PLN,

$k_{WP}(k)$ – hourly wages of k-th driver in PLN/h,

$k_{WU}(u)$ – hourly rate for rental u-th equipment in PLN/h,

$t_{PU}^C(c,u)$ – working time of u-th equipment in c-th transport cycle in h,

$\boldsymbol{U}(c)$ – set of numbers of equipment rented for the implementation of c-th transport cycle,

other designations as in formula (6).

Additional direct variable cost, differently than described above costs directly relate to a specific transport cycle and possibly supported in this cycle transport tasks. Thus, for the purposes of the calculation of the cost of transporting the extra costs should be divided into additional costs of the tasks of transport and additional costs other implementation cycle of lading. Taking into account the previously described classification of costs, these costs formally were written as follows:

$$K_D^{CI}(c) = K_{DP}^C(c) + K_{DW}^C(c) + K_{DD}^C(c) \quad \text{(PLN)}, \tag{13}$$

where:

$K_D^{CI}(c)$ – other than those arising from transported cargo specific direct variable cost implementing c-th transport cycle in PLN,

$K_{DP}^C(c)$ – costs of business trips of drivers in c-th transport cycle in PLN,

$K_{DW}^C(c)$ – additions to the salaries of drivers due in respect of execution of c-th transport cycle (remuneration for on-call time, for night work and overtime hours) in PLN,

$K_{DD}^C(c)$ – one-time charges for the use of transport infrastructure during implementing c-th transport cycle (charges for roads, tunnels, ferry crossings, intermodal trains) in PLN,

and:

$$K_D^Z(z) = K_{DU}^Z(z) + K_{DK}^Z(z) + K_{DZ}^Z(z) \quad \text{(PLN)}, \tag{14}$$

where:

$K_D^Z(z)$ – arising from transported cargo specific direct variable cost implementing z-th transport task in PLN,

$K_{DU}^C(z)$ – cargo insurance in z-th transport task in PLN,

$K_{DK}^C(z)$ – charges for cargo convoying in z-th transport task in PLN,

$K_{DZ}^{C}(z)$ – charges for licenses for the carriage of cargo transported in z-th transport task in PLN.

According to the introduced formalism, it is possible to identify the costs of implementing the transport cycle and costs specific to each transport tasks. Thus, to determine the implementation costs of transport tasks, it is necessary to separate transport costs of each transport cycle to implement in the transport tasks. This can be done using different divisional keys. In the article, having regard full loads transport was assumed, that the costs of implementation of transport cycle should be divided in transport tasks proportionally to related with implementation of these tasks loaded vehicles mileage. Formally, it was expressed as follows:

$$K^{Z}(z) = K_{D}^{Z}(z) + \sum_{c\in\mathbf{C}} \frac{Lp(c,z)}{\sum\limits_{z\in\mathbf{Z}(c)} Lp(c,z) + Lp(c,0)} \cdot (K_{A}^{C}(c) + K_{F}^{C}(c) + K_{PI}^{C}(c) + \\ + K_{K}^{C}(c) + K_{S}^{C}(c) + K_{P}^{C}(c) + K_{O}^{C}(c) + K_{N}^{C}(c) + K_{E}^{C}(c) + K_{W}^{C}(c) + K_{D}^{CI}(c)) \quad \text{(PLN)}, \tag{15}$$

where:

$K^{Z}(z)$ − total cost of implementing z-th transport task in PLN,

other designations as in formula (3)-(14).

5. Summary

Dimensioning of transport costs in road freight is of vital importance. It allows, in fact, determine the implementation costs of transport tasks and, consequently, prices of transport services. The use of inadequate transport services prices to costs incurred on the one hand can mean the loss of customers (prices too high), and on the other bankruptcy of companies (no cover their costs). The importance of this problem causes, that the calculation of costs must be done very carefully and in a clear manner. Because of the costs, diversity in transport frequently for their assignment to the transport tasks must be used so called dividing keys. Of course, these keys should be used consistently and must be factually justified.

The article approach allows in a transparent manner to perform the calculation of costs of implementing transport cycles and make the precise allocation of these costs to transport tasks performed by the company. Due to the assumptions adopted in the article, it can be used to calculate costs of implementing full truck transport tasks performed both in simple cycles (special case of presented approach) as well as in complex. Although attempts were made fairly to comprehensively include the costs of transport activities in road transport, however, in practice it may be necessary to complement presented approach of selected cost components. However, this should not cause any difficulty.

Not included problem in the article is taking into account, in the calculation of the costs, loss of money value in time. This leads to the use of discounting methods in the costs calculation, which is widely used in economic and financial analysis of investment projects[7].

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