

Methodology for predicting the transport costs of a product during the life cycle of a production device

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Abstrakt

As a result of the globalizing market is the product logistics becoming one of the important cost item within the whole lifecycle of production device. However, shipping costs are very difficult to predict because they can be affected by a number of factors. The objective of this article is to summarize the main factors influencing the transport costs of truck transport of the product and to introduce a proposal of methodology for estimation of transport costs of the product.

Keywords: Estimation of transport costs, Whole lifecycle of production device

1. Introduction

The current phenomenon encountered by manufacturing companies is the globalizing market for production inputs / outputs (input materials, semi-finished products, finished products). It is no longer unusual to take input material from China or the US by a central European company. There are many reasons for this phenomenon. The main things that can be mentioned are the meetings of companies producing input materials according to the "Assembly Act", which says that the unit costs of the product are falling down due to higher production quantities. In the same way, increasingly high demands on the quality and complexity of input materials are manifested. The associated high fixed costs of modern production processes logically lead to centralization of production at the cost of increased logistics needs. Although the increased need of logistics means the lowering of its cost, the cost of logistics becomes an important item in the entire life cycle of a product. The significance of this cost item is always influenced by the setting of payment terms (who bears the logistical costs), but in the end it will always be reflected in the final price of the product. Logistics costs include disposition, packaging, transport, handling and storage costs. The shipping cost item is affected by the way of shipping, transport requirements, and shipping distances. This article focuses on planning of the truck transport.

2. Truck transport

Truck (LKW) transport can be characterized as the transport of material and goods using different types of trucks running on the road network. It is one of the faster ways of transport and its use is very flexible. This flexibility is based not only on wide availability, but can also be used for the transport at short to long distances, where the road network is less restrictive than other modes of transport (rail, ship, air, pipeline).

2.1. Transport concepts

Various transport concepts can be encountered with truck transport. The first aspect is whether the truck goes one way (only from supplier to customer) or whether it returns /so-called "wheel"/. The "wheel" transport is often used to return of multiple circulation pallets. Another possible aspect is the way of transport concept. These concepts are:

- **Direct driving on a regular basis** - this is a concept of compact trucks moving directly from the supplier to the customer. Regularity in this case means better price and contract terms.
- **Direct one-way driving** - even in this case it is a compact truck going directly between the supplier and the customer. The main difference is the higher price resulting from the worse buyer bargaining position.
- **Milk run** - a kind of collecting ride that is used in the case that the suppliers are in a short distance to each other and is based on the principle of sequential loading of the truck, which travels gradually to individual suppliers.
- **Groupage** - Groupage is a transport concept used in the case of non-compact trucks. Incompleteness of a truck can be caused by small volumes or the necessity of frequent deliveries (it is not possible to wait for the truck to be completed). A consolidation center service is often incorporated into the collection process, where the small transport volumes from different suppliers are transported by freight wagons (often vans, etc.) to the warehouse where the truck is integrated and sent either directly to the customer or to another consolidation center from where they are distributed as individual contracts.

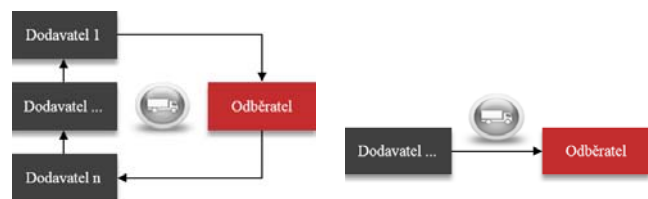


FIG. 1a

FIG. 1b

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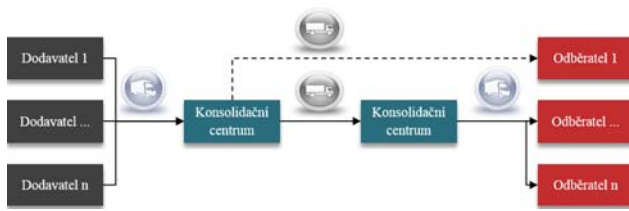


FIG. 1c

FIG. 1a) Direct driving scheme, 1b) Milk run scheme, 1c) Collecting service scheme - use of one consolidation center for customers 1 and use of 2 consolidation centers for other customers

2.2. Type of transport

Truck transport can be divided into local and international transport. The boundary of these terms is not fixed, but the 150 km distance and transport across multiple territories are used in practice.

- **Local transport** - this is often a truck transport within one country with a transport radius of 150 km. These services are most often charged at hourly rates. The hourly rate in Europe can range from 500 to 3,000 CZK / hour.
- **International carriage** - truck transport in the territory of several countries with transport radius more than 150 km. In international transport service is the transport charged at kilometer rates. Kilometer prices in Europe can range from 20 to 50 CZK per kilometer.

2.3. Charge transport costs

Prices charged for truck transport can vary greatly and their prediction is very difficult. The price is influenced by the choice of the transport concept, the type of transport, the means of transport, the frequency and the resulting contract prices, the current market situation and more. The aim of this predictive method is not to determine the cost of truck transport, but it is a rough planning tool that can be used for long-term planning based on the product life cycle. The methodology can be used both to determine the cost of truck logistics of input materials and final products. The methodology was designed for four countries. These are: the United States, the United Kingdom, the Czech Republic and China. To determine the difference in price levels for the cost unit (hour, kilometer), the following procedure was followed.

1. Defining the main items influencing the cost of the calculation unit,
2. Finding items for individual states,
3. Calculation of the price of the cost unit according to the price per 1 km.

2.3.1. Main items influencing the cost of the calculation unit

The main presumed items include leasing for tractor and trailer, fuel price, driver and maintenance costs. Details on individual items are given in Tables 1 and 3. Leasing is considered as a lease purchase. The price of the tractor and semi-trailer is determined as the sum of the advance payment and monthly installments provided by Walter-Leasing [6]. For simplicity, the annual lease payment is equal to the straight-line accounting depreciation of the facility. Taxes and fees vary from country to country, but the resulting costs without additional knowledge, such as the type of material being transported, the route of transport, and more cannot be clearly identified. Therefore, a flat rate was fixed for these two items.

TAB. 1) Main calculations inputs

SCANIA R500 (Kč)	2 750 800	KRONE Mega SDP 27 ¹ (Kč)	764 400
Depreciation period (year)	5	Lifetime (year)	8
Annual raid (km)	144 000	ø consumption (l/100km)	36,5
Tire price (Kč)	10 000	Number of tires (ks)	12
Maintenance cost (Kč)	360 000	Taxes / Other (Kč/km)	1
Fees (Kč/km)	3,5	Exchange rate (Euro / Dollar)	26,0/24,4

Driver costs are based on the driver's price in the Czech Republic and the wage value is given in the average wages in the countries under review for 2017 [3, 5]. The price of fuel is based on data from Global petrol prices [2].

TAB. 2) The average wage in individual countries and the ratio to the average wage in the Czech Republic. Fuel prices and their ratio to the average fuel price in the Czech Republic. The last column Comp. "Comparison" shows the price ratio of one kilometer in each country compared to the Czech Republic. The calculation is based on the data in Table 3.

State	Ø wage (Kč/r)	Wage (%)	ø diesel (Kč/l)	Diesel (%)	Comp. ks (%)
USA	1 470 159	253	18,8	57	116
UK	1 046 884	180	40,1	121	127
ČR	580 986	100	33,2	100	100
CH	251 411	43	22,5	68	74

¹ MEGA tarpaulin semi-trailer with dimensions of 13.60 x 2.45 x 3.00 m

TAB. 3) Overview of the main items influencing the cost of the calculation unit. Prices before the slash are given in Czech crowns per year. Values after the slash in brackets indicate the price of the item per kilometer. Items in blue are not considered to be a major change in the countries under review. Leasing corresponds to the amount of annual depreciation and the insurance is dealt with under the lease.

Item	USA	UK	ČR	CH
Leasing	703 040 /(4,9)	703 040 /(4,9)	703 040 /(4,9)	703 040 /(4,9)
Diesel	989 113 /(6,9)	2 106 682 /(14,6)	1 747 004 /(12,1)	1 181 797 /(8,2)
Main-tenance	910 964 /(6,3)	648 688 /(4,5)	360 000 /(2,5)	155 783 /(1,1)
Tires	115 200/(0,8)	115 200/(0,8)	115 200 /(0,8)	115 200 /(0,8)
Driver	1 434 769 /(10,0)	1 021 683 /(7,1)	567 000 /(3,9)	245 359 /(1,7)
Insurance	0 /(0,0)	0 /(0,0)	0 /(0,0)	0 /(0,0)
Taxes Others	144 000 /(1,0)	144 000 /(1,0)	144 000 /(1,0)	144 000 /(1,0)
Fees	504 000 /(3,5)	504 000 /(3,5)	504 000 /(3,5)	504 000 /(3,5)
Total	4 801 085 /(33,3)	5 243 292 /(36,4)	4 140 244 /(28,8)	3 049 179 /(21,2)

2.3.2. Local transport costs

The cost of local transport is based on an hourly cost rate. Since local truck transport is often contracted for a long time, contract prices may range up to 30%. The lower cost generally results in maximum capacity utilization of the tractor without downtime between orders. A frequent case of using local truck transport is internal company transport. For the model, the Sommer-also hourly cost rate [4] was used.

TAB. 4) Main input premise of local transport calculation

Hour rate HNS (Kč/h)	2 080	Ø tractor speed (km/h)	65
Lower transport limit (km)	0	Upper transport limit (km)	150
Loading time (min)	45	Unloading time (min)	30

$$t_{CELK} = t_N + t_C + t_V \quad (1)$$

$$t_C = v_{AVR} \cdot S_{P\acute{A}S} \quad (2)$$

$$TN_{LZ} = HNS \cdot t_C \cdot k_S \cdot k_{VP} \quad (3)$$

TAB. 5) Result values for selected local transport zones in individual countries, prices apply only for one-way transports

Distance (km)	LKW USA (Kč)	LKW UK (Kč)	LKW ČR (Kč)	LKW CH (Kč)
25	3 943	4 306	3 400	2 504
50	4 870	5 319	4 200	3 093
75	5 798	6 332	5 000	3 682
100	6 726	7 345	5 800	4 272
125	7 653	8 358	6 600	4 861
150	8 581	9 372	7 400	5 450

2.3.3. Cost of international transport

As mentioned above for international shipping, it is often charged on the basis of kilometers. This requirement takes into account the downtime resulting from mandatory driver stops, state border crossing and so on. The maximum distance traveled for international transport is not defined, but in practice we usually do not see longer distances of one route than 3 500 km. Longer routes are more often used by rail. The source of the Sommer-also price [4].

TAB. 6) Main input premise of the calculation of international transport

Price per kilometer (Kč/km)	39	-	-
Lower transport limit (km)	150	Upper transport limit (km)	3500

$$TN_{MZ} = p_{km} \cdot S_{P\acute{A}S} \cdot k_S \cdot k_{VP} \quad (4)$$

TAB. 7) Result values for selected local transport zones in individual countries, prices apply only for one-way transports

Distance (km)	LKW USA (Kč)	LKW UK (Kč)	LKW ČR (Kč)	LKW CH (Kč)
200	9 045	9 878	7 800	5 744
500	22 612	24 695	19 500	14 361
1 000	45 225	49 390	39 000	28 722
1 500	67 837	74 086	58 500	43 084
2 000	90 450	98 781	78 000	57 445
2 500	113 062	123 476	97 500	71 806
3 000	135 675	148 171	117 000	86 167
3 500	158 287	172 866	136 500	100 529

2.3.4. Price of transport according to transport concept

The choice of transport concept has a significant impact on the overall cost of transport. The above prices for local and international truck transport (Tables 5 and 7) correspond to the one-way direct drive transport concept. Other transport concepts usually mean a change in transport costs. Regular collection trips can be expected to reduce prices in the order of units to tens of percent. The supply of material or goods with the Milk run concept brings with it the cost of downtime resulting from multiple truck stops at different suppliers. Yet it is generally cheaper than collecting. Collecting rides lead to more manipulation and incorporation of the consolidation center into the transport process. The quantification of the significance of the concept's influence on the cost of transport costs is very difficult to predict. Nevertheless, coefficients of this effect (Table 7), which are rather conservative, have been set for gross transport cost planning. The reliability of the coefficients was consulted with the ŠKODA AUTO Transport Department.

TAB. 8) Conservative proposal of coefficients of the effect of transport concepts on the price of truck transport

Transport concepts	Coefficient
Direct driving on a regular basis	0,9
Direct one-way driving	1,0
Milk run	1,2
Groupage	1,3

2.3.5. Influence of LKW loading

The cost of the cost unit (kg, m3...) decreases as the load of the means of transport increases. The load limits are determined by volume or weight limits. The volume limits are given by the choice of semi-trailer (the KRONE Mega SDP 27 used in the calculation has a volume of 99.96 m3). The weight limits are based on the legal limits for road network load. This value varies from country to country. For countries under review, see table 9.

TAB. 9) Maximum possible trailer load in the monitored countries

State	Maximum load (kg)
USA	20 000 [1]
UK	26 000 [1]
ČR	26 600 [1]
CH	27 000 [7]

For the simplified procedure for estimating the number of pieces in LKW, 8 categories of parts were designed according to volume or weight.

TAB. 10) Part category for simplified piece count estimation in LKW, US-CH columns indicate the number of pieces in a given category that fit on a prescribed trailer. The number in front of the slash indicates the number of pieces in the given category, the number in brackets after the slash indicates the volume of the part in the given category.

Category	Weight (kg)	Volume (m3)	USA	UK	ČR	CH
A	250	0,5	80 / (150)	104 / (150)	106 / (150)	108 / (150)
B	500	1,0	40 / (75)	52 / (75)	53 / (75)	54 / (75)
C	750	1,5	26 / (50)	34 / (50)	35 / (50)	36 / (50)
D	1 000	2,0	20 / (37)	26 / (37)	26 / (37)	27 / (37)
E	1 250	2,5	16 / (30)	20 / (30)	21 / (30)	21 / (30)
F	1 500	3,0	13 / (25)	17 / (25)	17 / (25)	18 / (25)
G	1 750	3,5	11 / (21)	14 / (21)	15 / (21)	15 / (21)
H	2 000	4,0	10 / (18)	13 / (18)	13 / (18)	13 / (18)

2.3.6. Inflation element in calculation

Changes in transport prices are caused by many influences. Key factors include Table 1. However, driver

wages and fuel prices are the biggest drivers. As none of the parameters is subject to any regular development trends, their prediction using forecasting methods can bring a greater level of risk to the cost estimate than using solid current prices. In general, it is advisable to make maximum use of the inflation instrument to express the current price increase.

TAB. 11) Summary of the choice to use inflation to estimate the cost of truck transport

Fixed current prices	Considering inflation
+ Minimizes the effect of poor parameter estimation	+ It takes the value of money into account
- It does not reflect the change in input values	- Risk of correct interest rate development
Suitable for gross estimation	Suitable to use in a period of stable economic development

$$TN_{IN} = \sum_n^1 TN_{LZ/MZ} \cdot (1 + r)^n \quad (4)$$

2.3.7. Methodological procedure

To determine the transport cost estimate, we will start from the above premises. To estimate the costs according to the methodology set out here, it is necessary to know at least roughly the supplier / customer and the product for which the transport costs will be estimated. First of all, it is necessary to choose the country where the transport will be carried out. This option affects the cost of transports and weight constraints (Tables 2 and 9). The following is the selection of the transport concept according to the key given in Table 10. According to the supplier's distance is selected the transport and billing type (local transport - CZK / h; international transport - CZK / km). The following step adjusts the transport costs as needed for one-way / multi-way transportation. According to the gross product definition given in step one, the method of monitoring the LKW load is selected (volume / weight limitation of transport capacity = quantity of material / goods transported). In the next step, a choice must be made as to whether the element of inflation should be taken into account, or the transport costs estimated on the basis of fixed current prices (risks to be considered). In the last step, the calculation of the cost of the truck transport itself is already carried out.

TAB. 12) Transport concept key

Groupage (kg / m3)	Milk run (kg / m3)	Direct one-way driving (kg / m3)	Direct driving on a regular basis (kg / m3)
< 20 000 / 100	< 60 000 / 300	>= 20 000 / 100	>= 60 000 / 300
Irregular	Regular	Irregular	Regular

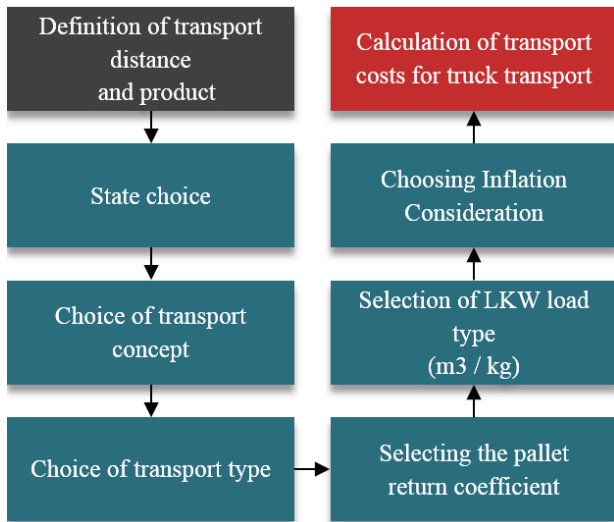


FIG. 2) Scheme of methodical procedure for estimation of truck transport costs

2.3.8. Example

The model results of the transport cost prediction determined using the described methodology will be demonstrated in the following example.

According to the strategy department, it is necessary to estimate the cost of transporting weldments for the planned construction of the hall at a distance of 200 km. Transported weldments are placed in standard 500 kg pallets. The total weight transported will be 60,000 kg. Transport will be realized in the following year, when the expected inflation is 3%. A stable economic development is expected. Returning of the wooden pallets is not considered. The aim is to compare the costs of transport in each of the monitored countries.

1. State: evaluation will be done for all evaluated states
2. Transport concept: transport 60 000 kg = direct regular ride
3. Type of transport: transport distance 200 km = international mode of transport
4. Pallet return coefficient: pallets do not return = 1
5. Selection of load type: transported object 500 kg = category B for weight load
6. Consideration of inflation: stable economic development = yes, time = one year, interest rate 3%

TAB. 13) Final transport prices

Item	USA	UK	ČR	CH
Basic LKW price (Kč)	9 045	9 878	7 800	5 744
Coef. Konceptu (-)	0,9	0,9	0,9	0,9
Coef. of returning pallets (-)	1	1	1	1
LKW price (Kč)	8 140	8 890	7 020	5 170
LKW price incl. inflation (Kč)	8 385	9 157	7 231	5 325
Number of LKW (ks)	3	3	3	3
Transport price (Kč)	25 154	27 471	21 692	15 975

3. Summary

The method described above allows, based on the knowledge of the basic characteristics of transport, to estimate the gross cost of truck transport in four countries of the world.

4. Conclusion

The prediction of truck transport costs will always be very difficult, as it is influenced by a number of external factors. The tool presented here does not aim to determine the exact cost of freight truck transport. The main objective is to present a simple tool for rough cost estimation based on the specification of a small number of restrictive criteria.

List of symbols

t_N	Loading time of semi-trailer (h)
t_C	Travel time (h)
t_V	Unloading time of trailer (h)
t_{CELK}	Total transport time (h)
v_{AVR}	Average speed (km/h)
SP_{AS}	Distance of the zone (from 0 km to 150 km)
k_S	km cost coefficient within the countries under review see table 2 column "comparison"
HNS	Hourly Cost Rate (Kč/h)
k_{VP}	Pallet Return Coefficients (takes 1 - one-way and 2 - wheel)
TN_{LZ}	Local Order Transport Costs (Kč)
P_{km}	Price per kilometre (Kč/km)
TN_{MZ}	Transport costs for international orders (Kč)
r	Interest rate
n	Years of discounting
TN_{IN}	Inflation Transport Costs

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