Cost Calculation in Transport Companies

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Abstract: Transport costs are often analysed by various macro- and micro economic models but detailed cost calculations within transport companies are hardly reported although this information is essential to control transport operations. Traditional as well as improved costing approaches can be implemented in transport management. If the examined transport company operates with considerable indirect costs it is worth applying the improved calculation methods. This paper aims at adapting the principles of multi-level full cost allocation to the specific characteristics of transport. The adaptation is performed through conducting a full-scale illustrative example. Based on the research results the advantages and the constraints of possible implementations are also considered.

Keywords: cost calculation, cost allocation, transport

1. Introduction

Calculating and analysing costs in transport companies is one of the most important tools of supporting decision making procedures [9]. Accurate cost data are the basis of setting prices, allocating resources or outsourcing various activities, etc. That is why special attention shall be paid to the methodology of cost calculations. Distortions in costing information may lead to inappropriate decisions which mitigate the operational efficiency of transport companies.

Transport costs are relatively often discussed in the literature. There can be found macroeconomic as well as microeconomic approaches dealing with this topic or its relating issues. From macroeconomic point of view the main research task is to determine the social costs of transport. So called transport accounts have been set up and studied to give estimations on transport related internal and external costs and revenues in aggregate levels (countries). The main challenge of this approach is to overcome the problems of lacking input data through using second best appraisal methods. Another task is to harmonise the definitions of cots categories so that consistent data bases can be built [14]. Another macroeconomic example is the evaluation of transport network expansion through elaborating and applying explicit econometric cost functions [12].

The microeconomic approaches analyse the cost structure of transport companies and branches or use transport costs for optimisations. For example rail costs are determined

on the basis of generally used cost drivers and compared to the charges applied in pricing systems [7]. Empirical research has been done in the field of bus transit operation costs. It has shown that physical and geographical characteristics are plausible explanatory cost factors of such transport services [8]. Cost data are often used for optimising the operation of various transport systems. For instance a freight distribution system has been improved by using a vehicle routing model minimising the transport costs [11]. Transport planning also uses cost data. An interesting research result in this field is that collaborative planning of transport tasks yields lower operating costs and cost savings shall be allocated to the participants in a transparent and fair way [10].

Although transport related researches frequently consider costs in the level of national economies or business companies, the detailed cost data within transport companies, i.e. the costs of elementary services or performance generators, are rarely investigated. Activity-based costing (ABC), as a well known calculation scheme, is used in some cases to give an insight into the mechanism of cost allocation in transport companies. For example a complete calculation of road freight transport service packages has been carried out by exploring the main cost drivers of relevant activities causing the indirect costs. This ABC application has showed that the cause-effect based allocation of indirect costs leads to more reliable cost data as compared to the outcomes of the traditional costing regimes [1]. Truck transport has been evaluated by other ABC models too [15]. Sophisticated numerical ABC examples of other transport modes could not be found in the literature reviewed. There are, however, some ABC applications in the field of logistics, like the analysis of logistics costs in a manufacturing company, etc. [13].

Beside ABC the multi-level full cost allocation (MFCA) technique can also be adapted to transport when there is a need of allocating indirect costs in an exact way. The basic principle of MFCA is similar to the one of ABC: indirect costs are allocated on the basis of measured performance relations or consumptions. The advantage of MFCA is that its models can depict the complex hierarchical operation structures and the intern service relations within them in a transparent way so that the cost efficiency within the company can be evaluated more effectively.

The aim of the further analysis is to give a guideline on how to apply MFCA in case of transport companies. The general model of transport costing has already been elaborated and serves here as a starting point [4, 5, 6]. Another input of the calculation is the sample costing model of a bus transport company [5]. The calculation is performed by making use of the experiences and formulas of other related pilot projects aimed to support decision making in rail transport and logistics [2, 3].

2. The calculation model

Figure 1 illustrates the sample cost calculation model set up for the case of a bus transport company. Bus services, as profit objects, are produced by the cost objects of drivers, vehicle types (#1…3) and sales. They contribute to the realisation of the profit objects by providing performances measured by the indicators of working time, vehicle km and transaction, respectively. The cost objects of drivers and vehicle types are controlled through dispositions of the operative commanding unit. Vehicle types are

served by the vehicle maintenance unit too. Here operation time drives the cost allocation. The performances of IT (information technology) and management cost objects are measured by data volumes and the number of orders respectively. They both serve the cost objects of sales, operative commanding and vehicle maintenance [5].

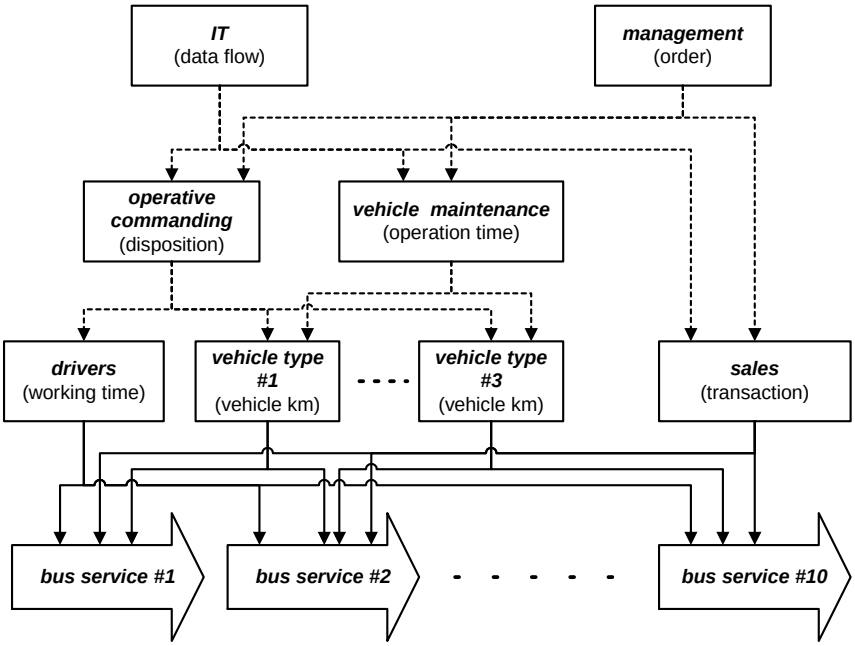

Figure 1. The calculation model

Equation (1) explains how to calculate the total cost of a cost object. The total cost of a cost object consists of the primary cost and the sum of the allocated intern service costs. Primary cost, representing a certain part of the total indirect costs in the company, is assigned to the cost object directly. The costs of the intern services are allocated to the cost object by using the ratios of relative performance consumptions. These are the so called performance intensities.

$$C_k^{co} = C_k^{pr} + \sum_{i=1}^{9} C_i^{sco} p_{ki}^{co} \text{ , } k = 1 \ldots 9 \tag{1}$$

where:

C_k^{co} : total cost of cost object k

C_k^{pr} : primary cost of cost object k

C_i^{sco} : total cost of service cost object i

p_{ki}^{co} : performance intensity, i.e. relative performance consumption, of cost object *k* at service cost object *i*

Equation (2) shows how to calculate the total cost of a profit object. The total cost of a profit object consists of the direct cost and the sum of the allocated intern service costs. The allocated intern service costs constitute the indirect cost of the profit object. Direct cost is assigned to the profit object directly. The costs of the intern services are allocated to the profit object by using the corresponding performance intensities.

$$C_j^{po} = C_j^d + \sum_{i=1}^{9} C_i^{sco} p_{ji}^{po} \ , j = 1 \ldots 10 \tag{2}$$

where:

C_j^{po} : total cost of profit object *j*

C_j^d : direct cost of profit object *j*

p_{ji}^{po} : performance intensity, i.e. relative performance consumption, of profit object *j* at service cost object *i*

It shall be noted that:

$$\sum_{k=1}^{9} p_{ki}^{co} + \sum_{j=1}^{10} p_{ji}^{po} = 1, \text{ for all } i = 1 \ldots 9 \tag{3}$$

Equation (4) is the formula of calculating the average cost of a cost object: the total cost is to be divided by the total performance. This, as the intern price of performance generation, can be used as the indicator of cost efficiency. So the cost efficiency of resource utilisation (e.g. human resource or vehicles) or of operating organisational units (e.g. sales, maintenance, etc.) can be determined exactly.

$$c_k^{co} = \frac{C_k^{co}}{P_k^{co}} \ , k = 1 \ldots 9 \tag{4}$$

where:

c_k^{co} : average cost of cost object *k*

P_k^{co} : total performance of cost object *k*

Through subtracting the total cost from the revenue the margin of a profit object (bus service) can also be determined according to Equation (5). The margin can be regarded as the indicator of profitability.

$$M_j^{po} = R_j^{po} - C_j^{po} \ , j = 1 \ldots 10 \tag{5}$$

where:

M_j^{po} : margin of profit object *j*

R_j^{po} : revenue of profit object *j*

3. Numerical example

The operation of the proposed cost calculation model can be illustrated by a numerical example. The input data, however, are estimated and assumed as real data could not be obtained yet. Nevertheless, the pilot calculation delivers enough information to form an opinion of the usefulness of the model.

The estimated performance intensities are summarised in Table 1. The rows represent the cost or profit objects receiving intern services while the service cost objects are listed in the columns.

Table 1. Performance intensities

r./s.	*IT*	*man.*	*opc.*	*v.m.*	*sal.*	*driv.*	*veh.1*	*veh.2*	*veh.3*
IT									
man.									
opc.	0.46	0.60							
v.m.	0.18	0.11							
sal.	0.36	0.29							
driv.			0.40						
veh.1			0.20	0.20					
veh.2			0.31	0.35					
veh.3			0.09	0.45					
ser.1					0.03	0.05	0.20		
ser.2					0.08	0.09	0.07	0.04	0.23
ser.3					0.13	0.07		0.18	
ser.4					0.21	0.17	0.13		0.21
ser.5					0.06	0.11		0.15	0.08
ser.6					0.12	0.08	0.14		0.11
ser.7					0.08	0.09	0.17		0.16
ser.8					0.06	0.15		0.43	
ser.9					0.13	0.12	0.29		0.13
ser.10					0.10	0.07		0.20	0.08

The estimated input data, like primary costs and performances, and the calculated data, like total costs and average costs, of cost objects are listed in Table 2. Equations (1) and (4) have been used for the calculations. The cost data are measured in thousand monetary units (th. MU) while the dimensions of performance and average cost data are indicated in the table. Looking at the average cost data the cost efficiency of various performance generations can be evaluated. This data can be compared to the similar data of previous years or to the similar data of other transport companies having the same operational structure. Even outsourcing decisions can be supported as average cost

data, as the prices of intern services, can be compared to the prices offered by extern service providers. So, for example, vehicle maintenance may be outsourced if the company has a price offer lower than 215.58 MU/hour, etc.

Table 2. Input and calculated data of cost objects

data	**pr. cost**	**total cost**	**performance**		**average cost**	
cost obj.	(th. MU)	(th. MU)	value	dimens.	value	dimens.
IT	50	*50.00*	3000	GB	*16.67*	MU/GB
man.	30	*30.00*	1500	no. ord.	*20.00*	MU/ord.
opc.	40	*81.00*	8800	no. disp.	*9.20*	MU/disp.
v.m.	850	*862.30*	4000	op. hours	*215.58*	MU/hour
sal.	330	*356.70*	54000	no. trans.	*6.61*	MU/trans.
driv.	1100	*1132.40*	23300	w. hours	*48.60*	MU/hour
veh.1	230	*418.66*	600000	veh. km	*0.70*	MU/vkm
veh.2	360	*686.92*	890000	veh. km	*0.77*	MU/vkm
veh.3	190	*585.33*	1200300	veh. km	*0.49*	MU/vkm

The estimated input data, like direct costs and revenues, and the calculated data, like total costs and margins, of profit objects are showed by Table 3. Equations (2) and (5) have been used for the calculations. All data in this table are measured in thousand monetary units (th. MU). The indirect costs within the total costs of profit objects are allocated on a cause-effect basis so they can be regarded as reliable. The margin data give a support for decision making on which bus services should be preferred and which ones should be rationalised or re-priced. The causes why certain operations are efficient or not and whether given services are profitable or not can be assessed exactly through analysing the performance generation chains in the model.

Table 3. Input and calculated data of profit objects

data	**direct cost**	**total cost**	**revenue**	**margin**
profit obj.	(th. MU)	(th. MU)	(th. MU)	(th. MU)
ser.1	100	*251.05*	260	*8.95*
ser.2	120	*441.86*	470	*28.14*
ser.3	90	*339.28*	310	*–29.28*
ser.4	150	*594.76*	550	*–44.76*
ser.5	180	*475.83*	500	*24.17*
ser.6	220	*476.39*	450	*–26.39*
ser.7	140	*435.28*	490	*54.72*
ser.8	120	*606.64*	570	*–36.64*
ser.9	110	*489.76*	440	*–49.76*
ser.10	80	*379.15*	460	*80.85*

To have an evidence of the correctness of the proposed model, it is worth comparing the results of MFCA with the results of the traditional cost calculation: see Table 4. In the traditional cost allocation scheme indirect costs are allocated to profit objects on the basis of direct cost ratios. The calculated data of Table 4 highlight that there are

significant differences between the results of the two different approaches. Note that the corresponding ABC applications have reported similar deviations [1].

The difference is caused by the fact that the traditional method ignores the heterogeneity of the transport service structure and assumes that the indirect operational costs are proportional to the direct costs. This is generally not true in complex transport companies running different services so the application of MFCA is proposed for their cost calculations. Of course, in smaller transport companies or in companies with a homogenous transport service structure traditional costing methods may also deliver satisfactory results. Nevertheless, in this case managers do not have the possibility to analyse the cause-effect chains of costs and performances.

Table 4. Results of traditional calculation

data ***profit obj.***	**total cost** (th. MU)	**difference** (th. MU)	**margin** (th. MU)
ser.1	*342.75*	*91.70*	*–82.75*
ser.2	*411.30*	*–30.56*	*58.70*
ser.3	*308.47*	*–30.81*	*1.53*
ser.4	*514.12*	*–80.64*	*35.88*
ser.5	*616.95*	*141.12*	*–116.95*
ser.6	*754.05*	*277.65*	*–304.05*
ser.7	*479.85*	*44.57*	*10.15*
ser.8	*411.30*	*–195.34*	*158.70*
ser.9	*377.02*	*–112.74*	*62.98*
ser.10	*274.20*	*–104.95*	*185.80*

4. Applicability

The MFCA transport costing model is able to support cost and performance management tasks by delivering more reliable information on the profits and costs of elementary transport services and on the cost efficiency of various operational units or resources. Another advantage of it is the transparent presentation of performance generating chains within the company. This model can mainly be utilised as an ex post analysing tool.

The model, however, is able to support even ex ante operational planning in transport management. Here the input data shall be forecast on the basis of former experiences and expected business or technology factors. The planned data can be compared to the fact data regularly and the interventions aiming at improving the transport operations can be made in time by analysing the causes of the deviations.

Another application area is the impact assessment of business process or technology reengineering. Introducing the effects of the improvements into the model makes it possible to investigate how they affect cost efficiency or profitability. Let us see an ex ante pilot impact analysis by using the model developed. Let us imagine that the IT modules of operative commanding, maintenance and sales are improved. It affects these units unequally: the IT subsystem of maintenance is moderately improved while the other two subsystems are significantly developed. The improvement leads to higher IT

costs and performances while the primary costs of operative commanding, maintenance and sales decrease due to saved workforce. The assumed changes in the data are the following:

- the primary cost of IT increases by 100% while its performance increases by 50%;
- the primary cost of operative commanding, vehicle maintenance and sales decreases by 25%, 5% and 25%, respectively;
- the performance intensities between IT and operative commanding, vehicle maintenance and sales change to 0.53, 0.06 and 0.41, respectively.

Running the model with the slightly modified data has given the results presented in Table 5. Accepting the assumed effects it can be concluded that the improvement of IT yields cost savings of bus transport services. The total cost of producing the services has decreased by 1.89%. So it is possible to estimate the cost savings of the IT improvement in a more exact way. Of course the reliability of the assumptions limits the applicability. Conducting similar sensitivity analyses enables more accurate operational cost or cost saving data needed for cost-benefit analyses of investments.

Table 5. Impact assessment of IT development

data ***profit obj.***	**total cost** (th. MU)	**cost saving** (%)	**margin** (th. MU)
ser.1	*248.65*	*0.96*	*11.35*
ser.2	*432.78*	*2.06*	*37.22*
ser.3	*330.36*	*2.63*	*–20.36*
ser.4	*579.04*	*2.64*	*–29.04*
ser.5	*470.19*	*1.19*	*29.81*
ser.6	*467.13*	*1.95*	*–17.13*
ser.7	*427.38*	*1.81*	*62.62*
ser.8	*600.08*	*1.08*	*–30.08*
ser.9	*479.08*	*2.18*	*–39.08*
ser.10	*370.32*	*2.33*	*89.68*

Despite its advantages the practical implementation of the MFCA model may have several constraints. The main barrier of introducing MFCA in transport is the lack of high quality input data, which may require additional estimations. Another problem is that the operational structure of the real-world transport companies can not be depicted perfectly in the model and generally simplifications are needed. It makes the model applicable but at the same time the correctness of the results declines. Nevertheless, if the operation or the service structure of the transport company is complex or heterogeneous and there is an intention to make the management information system more accurate, it is worth considering the introduction of MFCA.

5. Conclusions

The adaptation of MFCA to the specific features of transport companies and the implementation of related costing models deliver real advantages for decision makers.

One of the advantages is the more accurate and detailed cost, cost efficiency and profitability information of operational units or services in transport companies. The output data base of MFCA contains much smaller distortions due to the cause-effect based indirect cost allocations.

Another advantage of the new costing regime is the ability to carry out more sophisticated analyses, i.e. exploring the causing factors of profits or losses, determining the efficiency of operations or the viability of transport services, investigating the impacts of business or technology improvements, etc. Even the management related procedures of transport planning can be supported when both plan and fact data are fed into the model and the plan-fact deviations and their influencing factors are then evaluated carefully. This function of MFCA enables the decision makers to control transport management procedures effectively and in a transparent way.

Considering the constraints of MFCA it can be concluded that the operation of transport companies can not be modelled perfectly in practice. Some simplifications have to be included when depicting the organisational and service structures, which may make the calculation results less accurate. These results, however, are in general still more correct than the outputs of traditional costing approaches. It shall also be taken into account that MFCA calculations require more and high quality input data than the other cost management tools do, which may need more efforts from the users and maintainers of management information systems.

Comparing the advantages and disadvantages of MFCA it can be stated that this kind of cost calculation is worth implementing in case of transport companies operating with complex organisational structures causing considerable indirect costs and/or their service structures are extensive and not homogeneous.

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