Integrating Logistics Cost Calculation into Production Costing

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Abstract: Production costing is a well developed area of cost management. There are several applications reported which make use of the up-to-date costing methods like activity-based costing. Nevertheless, research in product cost calculation has paid limited attention to logistics costing so far. This paper aims to investigate how logistics cost calculation can be integrated into production costing. The methodology applied relies on the multi-level indirect cost allocation technique as it corresponds to the nature of logistics costs appearing in production systems. The proposed costing model is tested by a numerical example. Based on the research results, it can be concluded that the integration of logistics functions into production costing yields clear advantages; however, its implementation may require considerable efforts and also some compromises concerning the methodological constraints.

Keywords: cost calculation; cost allocation; performance; logistics; production

1 Introduction

Logistics has become an important factor influencing the competitiveness of production companies. The logistics functions of production cover activities such as the procurement of inputs, the supply of manufacturing processes and the distribution of finished products. It is essential that reliable data are available on the costs and performances of these logistics operations so that the management decisions affecting logistics issues in production systems can be supported more effectively.

Production costing is a widely investigated and analysed topic in the literature. There are numbers of approaches on how to make the cost calculation of various products created in different manufacturing systems more accurate. As production processes can generally be planned and modelled in an exact way, the costing methods used have reached a high level of completeness. Although production companies have already recognised the importance of logistics functions, less attention has been paid to the independent evaluation of their costs and performances. To carry out such evaluations is often not possible as production costing regimes are not sophisticated enough to distinguish logistics related operations.

Thus it is worth examining how the calculation of logistics costs and the monitoring of logistics cost effectiveness can be incorporated into production costing. To do that, the first task is to review the literature and identify the relevant methodological background. Having defined the research framework, the principles of the proposed costing mechanism are elaborated by also taking into account the outcomes of relevant R&D projects and former publications. The modelling procedure aims at creating and demonstrating a possible production costing scheme which is able to determine the contribution of logistics functions to the product costs, and moreover, to evaluate the cost effectiveness of logistics activities operated in production companies.

Concerning the methodology, the multi-level indirect cost allocation approach is applied when setting up the costing model. It is a special form of the full cost allocation (FCA) technique. The application of this method is necessary because logistics-related costs emerge usually as indirect costs in production companies.

Another suitable approach could be the activity-based costing (ABC) technique, which is a widely accepted and utilised method of production costing – to be described further on. Nevertheless, ABC does not pay too much attention to the interactions between cost centres operating on various levels of the organisational hierarchy. Logistics functions, however, can be found in different levels of the production structure so a costing method considering the multi-level characteristics or the vertical integration of production may be more appropriate.

To illustrate the advantages of the proposed costing method, a pilot calculation is also carried out. It is not a real-life application as the input data are based on estimations. Nonetheless, the sample model depicts the operation of a typical production company having background logistics functions. So the experiences obtained through running this simple model may be relevant for drawing general conclusions. Of course, real-life implementations would need a sound adaptation of the developed costing model as each production company has its own operational specifications.

2 Methodological Background

Before developing the product cost calculation model including logistics functions, the relevant literature shall be studied carefully. The literature review covers production costing with special regard to logistics related subtopics.

Several case studies were conducted to find out what models of product costing the companies use and what allocation bases are applied. It was pointed out that accounting systems are mostly designed to meet financial accounting demands, so an additional costing model is necessary for product costing. Companies try to do their cost allocations as logically as possible within a limited timeframe and with other scarce resources. The main purpose of the introduction of product costing models is pricing and inventory valuation where the latter factor is usually less important [1].

Full-absorption costing, i.e. direct cost based overhead allocation, has often been criticised. It used to be a suitable tool, as long as the ratio of direct costs was high in production systems. Today's production systems are, however, automated complex systems with a high ratio of indirect costs where ABC can be applicable. Nevertheless, ABC as a parameter based method may require considerable resources. The costs of ABC can be reduced by using simulations [17].

ABC has been successful mainly in large scale industries by providing appropriate and accurate information on the consumption of resources. At the same time ABC has not received significant attention from small companies, which is why attempts have been made to study the application of ABC in such companies as well. The related projects aimed to develop ABC systems in order to produce more accurate cost information and provide information for making or buying, i.e. outsourcing decisions [13].

Several authors state that ABC has become a mature cost estimation and accounting methodology. Using ABC for cost estimation of manufactured parts is being practiced with an acceptable rate of success. A special application area is where the costs of the design and development activities for machined parts are evaluated. An essential conclusion of such assessments is that the discrepancy between ABC and traditional cost estimates grows as the products become more and more complex [3].

An attempt was made to integrate the benefits of ABC with other management principles like throughput accounting, target costing, life cycle costing and strategic accounting in order to establish a more realistic costing model of complex manufacturing processes. Although each model has its own particular merits, the common elements of them are the strong emphasis on business processes and the inclusion of relevant manufacturing characteristics, i.e. performance [11].

The production ABC models can be combined with other parameter based methods. These combined approaches can mainly be applied in the planning phases [19]. So ABC can be used as a planning tool and opens the possibility of applying more sophisticated planning procedures to tactical optimisation problems within production and operations management [21]. Even business process reengineering (BPR) evaluations can be carried out through using ABC [22]. Another example is when the quantitative determination of cost reduction through task learning is performed using ABC, and then it is compared with traditional costing. Results obtained by these two techniques may be significantly different [2].

Logistics costs within production companies can only be separated in a difficult way. The reported logistics cost data are not accurate and their cause-effect mechanism cannot be evaluated either. So the effective control of logistics costs and the rationalisation of logistics activities are missing [6, 23]. A possible solution may be the introduction of ABC, as it is applicable to allocate indirect costs such as logistics costs. ABC can also be combined with the economic value added (EVA) method, which enables the inclusion of capital costs [23].

ABC is claimed to be an appropriate technique in computing the costs in production systems producing products according to a make-to-order principle. An extensive ABC model for evaluating the change in the production supply system was established with a detailed activity and cost driver analysis for company-intern storage systems. It has been concluded that ABC is the most suitable methodology in allocating the costs of indirect activities, such as storing and materials handling, which do not directly add value to the manufacturing of the product [20].

ABC is applied for determining inventory costs, which makes it possible to control inventory operations [4]. A dedicated costing system for order management in manufacturing companies using ABC and activity-based management (ABM) has been developed and integrated as a decision support system [14]. Modern manufacturing systems using material requirement planning (MRP) or just in time (JIT) supply techniques are evaluated by product cost calculation based on ABC. It has been proved that the push and the pull type supply systems can be compared with each other effectively through using improved logistics costing [18].

The literature review causes us to make the conclusion that although logistics costing elements can already be found in production costing, the independent and separate calculation or evaluation of logistics costs and performance are not typical in production systems. Another interesting finding is that almost all product costing projects, independently from the scope, rely on activity-based costing. It is also obvious that the accuracy and the usefulness of production costing can be improved significantly by the introduction of separate logistics costing functions.

As a consequence of the literature analysis it can be stated that the adoption of multi-level indirect cost allocation with special regard to logistics functions will probably deliver real advantages to product costing. By doing so, even the efficiency of logistics activities or operations performed in production companies may become visible.

3 The Proposed Costing Model

The production costing model supplemented with logistics cost calculation functions is built up in two steps:

1. defining the general structure of the costing model based on multi-level indirect cost allocation;
2. developing a concrete costing model depicting the operation of a sample production company having logistics business units/areas.

The first step utilises the research results published by the author of this paper [5, 8, 9, 10]. The general principles have already been elaborated but now shall be adapted to the specific needs of production costing. Special attention is paid to the integration of logistics related objects and relations. The basic ideas of the second step are also available [9]. Nevertheless, they need to be completed to make the model more comprehensive and consistent.

Figure 1 shows the general costing model based on multi-level indirect cost allocation. The model consists of cost objects, profit objects and relations connecting the objects.

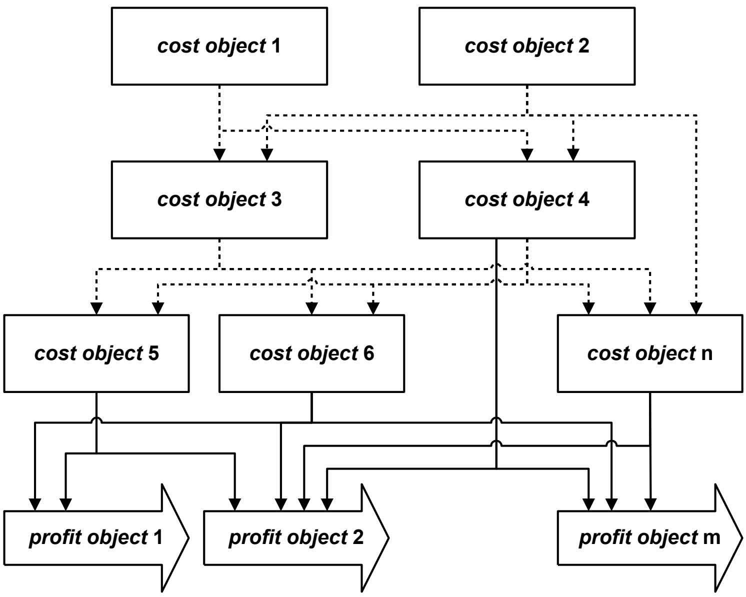

Figure 1

General costing model based on multi-level indirect cost allocation

The cost objects are entities where the indirect costs are registered as primary costs. They are arranged into a multi-level hierarchy – which is why this is a scheme of multi-level indirect cost allocation. Cost objects can be business units or technology centres contributing to the production of the profit objects or they might serve other cost objects. Each cost object shall be supplied with a performance indicator measuring its performance. These performance indicators are the so-called cost drivers.

Profit objects are the products which obtain revenues for the company. Direct costs are recorded in the profit objects. Note that the definition of model elements (objects) is different from the one of ABC: ABC uses cost/activity centres instead of cost objects and cost objects instead of profit objects.

The relations in the model reflect the performance consumption. As the cost objects have intern service relations with each other their total costs also contain the so called secondary costs which can be allocated by using the rate of the relative performance consumption, called performance intensity. So the total cost of cost object *k* can be calculated as follows:

$$TC_k^{co} = C_k^{pr} + \sum_{i=1}^{n} TC_i^{sco} \frac{P_{ki}^{co}}{TP_i^{sco}} = C_k^{pr} + \sum_{i=1}^{n} TC_i^{sco} p_{ki}^{co} \text{ , } k = 1, 2, \ldots, \mathrm{n} \qquad (1)$$

where:

TC_k^{co} - total cost of cost object *k*

C_k^{pr} - primary cost of cost object *k*

TC_i^{sco} - total cost of serving cost object *i*

TP_i^{sco} - total performance of serving cost object *i*

P_{ki}^{co} - performance consumption of cost object *k* at serving cost object *i*

p_{ki}^{co} - performance intensity of cost object *k* at serving cost object *i*

Moreover, the allocation of the indirect costs to the profit objects from the relevant serving cost objects are also based on the relative performance consumption. So the total cost of profit object *j* can be calculated as follows:

$$TC_j^{po} = C_j^{d} + \sum_{i=1}^{n} TC_i^{sco} \frac{P_{ji}^{po}}{TP_i^{sco}} = C_j^{d} + \sum_{i=1}^{n} TC_i^{sco} p_{ji}^{po} \text{ , } j = 1, 2, \ldots, \mathrm{m} \qquad (2)$$

where:

TC_j^{po} - total cost of profit object *j*

C_j^{d} - direct cost of profit object *j*

TC_i^{sco} - total cost of serving cost object *i*

TP_i^{sco} - total performance of serving cost object *i*

P_{ji}^{po} - performance consumption of profit object *j* at serving cost object *i*

p_{ji}^{po} - performance intensity of profit object *j* at serving cost object *i*

It shall be noted that:

$$\sum_{k=1}^{n} p_{ki}^{co} + \sum_{j=1}^{m} p_{ji}^{po} = 1, \text{ for all } i = 1, 2, \dots, n \quad (3)$$

It is obvious that performance indicators or performance intensities play a crucial role in the allocation procedure. Thus the selection of cost drivers and the measurement of performance distribution shall be carried out carefully. Besides technology information systems, the experiences of experts or managers responsible for the examined activity areas may be useful here.

If we would like to add mathematical methods when selecting cost drivers, regression or correlation analysis may be applicable, provided the time series of cost and performance data are available. If the proposals of experts can be obtained and they are ready to rank them, the analytical hierarchy process (AHP) methodology may give more exact results. AHP can also be used in extreme cases when the distribution of performances cannot be measured; here the weights resulting from the AHP calculation are regarded as performance intensities [7].

The cost efficiency of the cost object can be evaluated by calculating the average cost: total cost divided by performance. A high value of average cost may reflect a low level of capacity utilisation. Average cost values can also be used for preparing outsourcing decisions as the prices of extern services can be compared with the intern cost of performance creation.

Note that efficiency is a broader issue than cost efficiency. There are much more complex methods for evaluating the efficiency of certain business or technology units. Cost efficiency is one of the indicators measuring efficiency and shall be supplemented by other instruments, e.g. data envelopment analysis (DEA), when making complex assessments [15, 16]. DEA can even be combined with AHP, which yields a wider range of the efficiency ranking values [12].

Revenues are recorded in the profit objects. The margin of the profit object, as the indicator of its profitability, can be calculated by subtracting the total cost form the revenue. Another indicator of profitability is the cost-coverage ratio which can be determined through dividing the total cost by the revenue.

How can the logistics functions be incorporated into the general production cost calculation scheme defined before? Logistics functions in production companies are mainly background services of the core activity, i.e. manufacturing. Sometimes they serve the products itself. So logistics functions can be regarded as cost objects causing indirect costs and producing performances as intern services. They can be assigned to different levels of the cost object hierarchy depending on the organisational structure of the examined company. Another condition of adding logistics cost objects is the separated registration of logistics cost items and the separate measurement of performance indicators or intensities [6].

As logistics functions are cost objects in our model their cost efficiency becomes calculable through the average costs. These are indicators for supporting outsourcing decisions which are frequently considered in case of in-house logistics services. Due to the cause-effect based allocation of logistics costs, as indirect costs, the ratio of logistics cost in the total product cost can also be determined in a more exact way. Summarising the argumentation it can be stated that our theoretical model meets the methodological requirements set before (see Chapter 1).

Having built the general model, the concrete costing scheme is to be developed in the second step. It means that the appropriate profit and cost objects shall be selected, and then the intern service connections or performance relations between them shall be identified. Performance indicators and their dimensions are also to be added.

Here a rather general cost model of a production company is considered on the basis of empirical experiences. The basic structural elements have been gained by former research results [9]. At the same time, the model is further developed by including additional operational elements. The proposed costing model is shown in Figure 2.

The elementary profit objects in the sample model are the products (1…m). Their direct inputs are materials used and components mounted which represents the direct costs. The cost objects can be categorised into two groups:

1. the cost objects representing the general activity areas of the company (levels 5…6), such as general, financial or human management and IT (information technology);
2. the cost objects representing the units of tactical and operative control or execution (levels 1…4), such as production planning, purchasing, operative production control, maintenance, sales, distribution, production supply and manufacturing (1…x). This group is served by the cost objects of Group 1 and it serves the profit objects. There are also further intern service relations within this group, which can be seen in Figure 2.

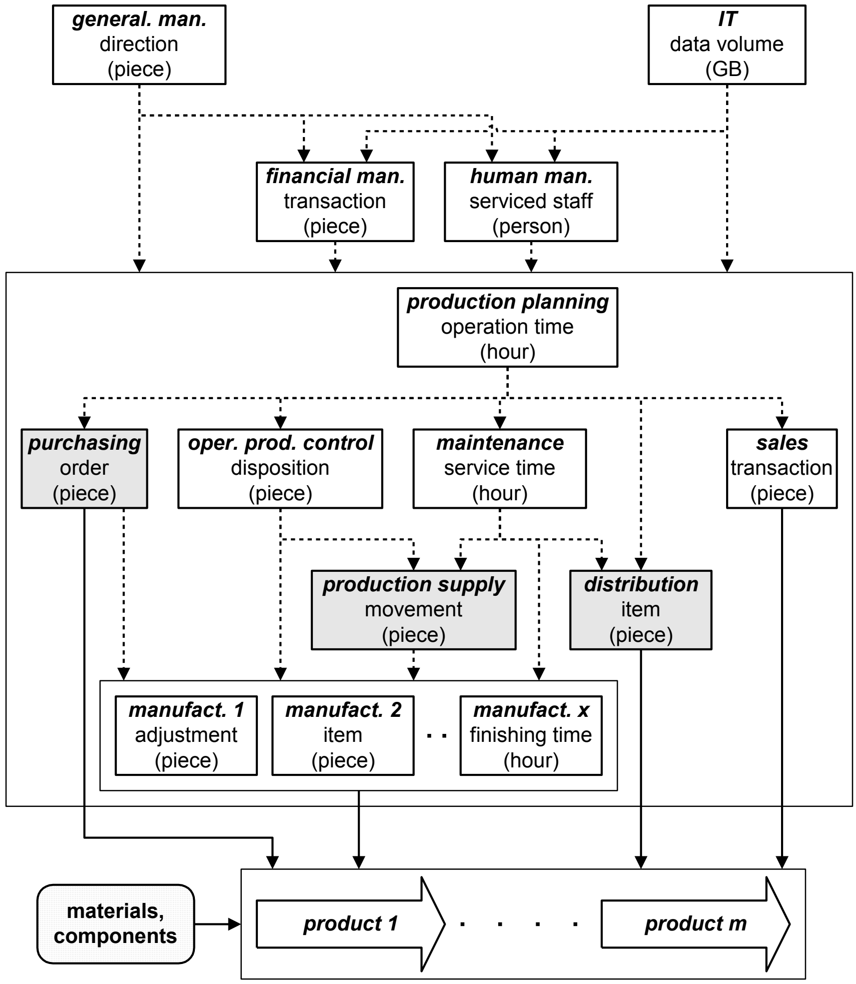

Figure 2

Costing model of a sample production company having logistics functions

Let us see how the logistics functions are integrated into the cost allocation mechanism or operation model:

- purchasing is assigned to allocation level 3. It is served by the cost objects of Group 1 and by production planning. It serves manufacturing and products. Its performance indicator is order with the dimension of piece (i.e. number of orders);
- production supply is assigned to allocation level 2. It is served by the cost objects of Group 1 and by operative production control and maintenance. It serves manufacturing. Its performance indicator is movement with the dimension of piece (i.e. number of movements);

- distribution is assigned to allocation level 2. It is served by the cost objects of Group 1 and by production planning and maintenance. It serves the products. Its performance indicator is item with the dimension of piece (i.e. number of items).

4 Numerical Example

The advantages of the proposed cost calculation model can be revealed through completing a numerical example. This example demonstrates the operation, i.e. the procedures of the costing model. The input data necessary for running the model have been estimated. So not the numerical results itself but the functions supporting the decision making tasks shall be studied and evaluated.

Let us assume that our sample production company operates according to the model presented by Figure 2. It has 10 products (m = 10) and 3 manufacturing sites (x = 3). The assumed direct cost and revenue data for the profit objects (products 1-10) are summarised in Table 1 where "th. MU" means thousand monetary unit.

Table 1

Estimated direct costs and revenues for profit objects

profit object	**direct cost** C_j^d (th. MU)	**revenue** (th. MU)
product 1	400	960
product 2	380	890
product 3	340	870
product 4	560	910
product 5	540	1200
product 6	680	1540
product 7	430	1320
product 8	520	1380
product 9	420	1210
product 10	300	1050

The assumed primary cost (representing the indirect costs) and performance data of cost objects can be found in Table 2. The cost objects and their performances are listed on the basis of Figure 2.

To complete the cost allocations by using Equations (1) and (2) the performance intensities shall also be made available as input data. The cause-effect relations of Figure 2 helps identify what performance intensity data are needed.

Table 2

Estimated primary costs and performances for cost objects

cost object	**primary cost** C_k^{pr} (th MU)	**performance** TP_i^{sco}	
		value	***dimension***
gen. man.	40	2,800	(piece)
IT	80	5,900	(GB)
fin. man.	60	55,000	(piece)
hum. man.	40	290	(person)
prod. plan.	60	5,400	(hour)
purchas.	180	22,000	(piece)
prod. cont.	90	4,800	(piece)
mainten.	780	12,000	(hour)
sales	330	38,000	(piece)
distribut.	630	19,000	(piece)
prod. sup.	520	150,000	(piece)
manuf. 1	760	120,000	(piece)
manuf. 2	660	14,000	(piece)
manuf. 3	870	13,000	(hour)

Table 3

Estimated performance intensities between cost objects

p_{ki}^{co} **(rec./ser.)**	***g. m.***	***IT***	***f. m.***	***h. m.***	***prod. p.***	***purch.***	***prod. c.***	***maint.***	***p. sup.***
fin. man.	0.12	0.16							
hum. man.	0.11	0.13							
prod. plan.	0.14	0.09	0.05	0.06					
purchas.	0.09	0.11	0.19	0.06	0.24				
prod. cont.	0.04	0.12	0.05	0.05	0.30				
mainten.	0.07	0.07	0.09	0.11	0.16				
sales	0.12	0.11	0.24	0.06	0.12				
distribut.	0.08	0.06	0.11	0.07	0.18			0.10	
prod. sup.	0.02	0.03	0.03	0.05			0.13	0.08	
manuf. 1	0.08	0.04	0.08	0.19		0.12	0.29	0.25	0.35
manuf. 2	0.07	0.05	0.09	0.18		0.15	0.26	0.27	0.32
manuf. 3	0.06	0.03	0,07	0,17		0.14	0.32	0.30	0.33

Table 3 contains the assumed performance intensities determined for the performance consumptions identified between cost objects. The objects receiving (consuming) performances can be found in the first column while the objects providing (serving) performances are listed in the first row of the tables. Table 4 demonstrates the assumed performance intensities determined for the performance consumptions identified between cost and profit objects.

Table 4

Estimated performance intensities between cost and profit objects

p_{ji}^{po} (rec./ser.)	***purchas.***	***sales***	***distribut.***	***manuf. 1***	***manuf. 2***	***manuf. 3***
product 1	0.04	0.10	0.09	0.08	0.12	0.07
product 2	0.05	0.08	0.09	0.13	0.04	0.11
product 3	0.04	0.11	0.08	0.18	0.03	0.09
product 4	0.07	0.09	0.10	0.06	0.15	0.05
product 5	0.06	0.07	0.11	0.03	0.11	0.17
product 6	0.05	0.08	0.08	0.09	0.08	0.10
product 7	0.09	0.12	0.14	0.12	0.11	0.06
product 8	0.08	0.10	0.11	0.14	0.07	0.11
product 9	0.06	0.12	0.09	0.05	0.19	0.09
product 10	0.05	0.13	0.11	0.12	0.10	0.15

In possession of the input data, calculation can be started. At first, the secondary cost, total cost and average cost data of cost objects are to be determined using Equation (1) by taking into account the corresponding cause-effect chains. Note that the sequence of the allocations is fixed; the costs of the cost objects in the lower levels can be calculated only after the costs of all preceding cost objects in the upper levels have already been calculated. The results are shown in Table 5.

Table 5 has been constructed by taking the fixed calculation sequence into account. Let us see how to calculate the resulting data of logistics cost objects by inserting the relevant input data and the preceding calculated data. The total cost of purchasing is 180 + 40.00 * 0.09 + 80.00 * 0.11 + 77.60 * 0.19 + 54.80 * 0.06 + 79.97 * 0.24 = 180 + 49.62 = 229.62 th. MU. The average cost is 229.62 / 22,000 * 1,000 = 10.44 MU/piece (MU/order).

The total cost of distribution is 630 + 40.00 * 0.08 + 80.00 * 0.06 + 77.60 * 0.11 + 54.80 * 0.07 + 79.97 * 0.18 + 814.21 * 0.10 = 630 + 116.19 = 746.19 th. MU. The average cost is 746.19 / 19,000 * 1,000 = 39.27 MU/piece (MU/item).

The total cost of production supply is 520 + 40.00 * 0.02 + 80.00 * 0.03 + 77.60 * 0.03 + 54.80 * 0.05 + 131.81 * 0.13 + 814.21 * 0.08 = 520 + 90.54 = 610.54 th. MU. The average cost is 614.54 / 150,000 * 1,000 = 4.07 MU/piece (MU/movement).

Table 5

Calculated secondary costs, total costs and average costs of cost objects

cost object	secondary cost (th. MU)	total cost TC_k^{co} (th. MU)	average cost	
			value	***dimension***
gen. man.		40.00	14.29	(MU/piece)
IT		80.00	13.56	(MU/GB)
fin. man.	17.60	77.60	1.41	(MU/piece)
hum. man.	14.80	54.80	188.97	(MU/person)
prod. plan.	19.97	79.97	14.81	(MU/hour)
purchas.	49.62	229.62	10.44	(MU/piece)
prod. cont.	41.81	131.81	27.46	(MU/piece)
mainten.	34.21	814.21	67.85	(MU/hour)
sales	45.11	375.11	9.87	(MU/piece)
distribut.	116.19	746.19	39.27	(MU/piece)
prod. sup.	90.54	610.54	4.07	(MU/piece)
manuf. 1	506.04	1,266.04	10.55	(MU/piece)
manuf. 2	507.57	1,167.57	83.40	(MU/piece)
manuf. 3	539.61	1,409.61	108.43	(MU/hour)

Having calculated the output data of cost objects, similarly as in the case of logistics cost objects, it is possible to determine the indirect costs, total costs, margins and cost coverages of profit objects (products) by using Equation (2). The results are indicated in Table 6.

Table 6

Calculated indirect costs, total costs, margins and cost coverages of profit objects

profit object	indirect cost (th. MU)	total cost TC_j^{po} (th. MU)	margin (th. MU)	cost coverage (%)
product 1	453.92	853.92	106.08	112.42
product 2	474.99	854.99	35.01	104.09
product 3	499.92	839.92	30.08	103.58
product 4	446.03	1,006.03	-96.03	90.45
product 5	528.16	1,068.16	131.84	112.34
product 6	449.50	1,129.50	410.50	136.34
product 7	535.08	965.08	354.92	136.78
product 8	551.99	1,071.99	308.01	128.73
product 9	537.95	957.95	252.05	126.31
product 10	622.45	922.45	127.55	113.83

Let us see, for example, how to calculate the output data of product 1. The total cost is 400 + 229.62 * 0.04 + 375.11 * 0.10 + 746.19 * 0.09 + 1,266.04 * 0.08 + 1,167.57 * 0.12 + 1,409.61 * 0.07 = 400 + 453.92 = 853.92 th MU. The margin is 960 – 853.92 = 106.08 th. MU, while the cost coverage ratio is 960 / 853.92 * 100 = 112.42%. The other product costs, margins and cost coverages can be determined similarly.

As the relevant cause-effect relations have been identified in the costing model, the logistics costs of the products can also be calculated. Table 7 shows the so-called restricted logistics costs of the products including also the ratio of logistics costs within total product costs. Restricted logistics cost means that only the primary costs of the logistics cost objects are considered and allocated here on the basis of the multi-level performance consumptions.

Table 7
Restricted logistics costs of products

profit object	**purchas.** (th. MU)	**prod. sup.** (th. MU)	**distribut.** (th. MU)	**total l. cost** (th. MU)	**ratio of l. cost** (%)
product 1	13.93	46.54	56.70	117.17	13.72
product 2	15.66	49.19	56.70	121.55	14.22
product 3	14.17	53.20	50.40	117.76	14.02
product 4	19.21	44.46	63.00	126.67	12.59
product 5	18.70	52.94	69.30	140.94	13.19
product 6	15.62	46.85	50.40	112.88	9.99
product 7	23.27	50.44	88.20	161.91	16.78
product 8	22.09	56.00	69.30	147.39	13.75
product 9	19.28	56.16	56.70	132.14	13.79
product 10	18.07	64.22	69.30	151.59	16.43

Let us see, as an example, how to calculate the logistics cost of product 1:

- cost of purchasing (cost items are allocated directly and also through manufacturing cost objects): 180 * 0.04 + 180 * 0.12 * 0.08 + 180 * 0.15 * 0.12 + 180 * 0.14 * 0.07 = 13.93 th. MU (to make it clear Figure 3 illustrates this allocation procedure);
- cost of production supply (cost items are allocated through manufacturing cost objects): 520 * 0.35 * 0.08 + 520 * 0.32 * 0.12 + 520 * 0.33 * 0.07 = 46.54 th. MU;
- cost of distribution (cost items are allocated directly): 630 * 0.09 = 56.70 th. MU.

Note, when the cost allocation is carried out directly it does not mean that the corresponding cost items are direct costs. They are indirect costs as they cannot be registered in the profit objects directly and need additional assignments on the basis of performance consumption. However, this assignment is carried out in one step.

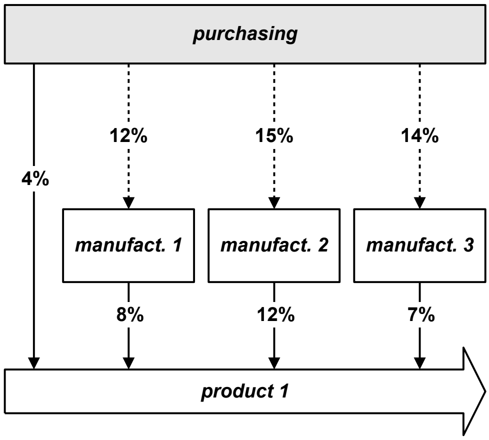

Figure 3
Allocation of purchasing costs to product 1

So the total logistics cost of product 1 is 13.93 + 46.54 + 56.70 = 117.17 th. MU. The ratio of logistics cost in the total product cost is 117.17 / 853.92 *100 = 13.72%. The logistics costs and cost ratios of the other products can be determined similarly. If it is not the primary costs but the total costs of logistics cost objects (i.e. 229.62, 610.54 and 746.19 th MU instead of 180, 520 and 630 th. MU) which are considered and allocated; then the so called extended logistics costs of the products are determined. The results are shown in Table 8.

Table 8
Extended logistics costs of products

profit object	**purchas.** (th. MU)	**prod. sup.** (th. MU)	**distribut.** (th. MU)	**total l. cost** (th. MU)	**ratio of l. cost** (%)
product 1	17.77	54.64	67.16	139.57	16.35
product 2	19.98	57.76	67.16	144.89	16.95
product 3	18.07	62.46	59.69	140.22	16.69
product 4	24.50	52.20	74.62	151.32	15.04
product 5	23.86	62.15	82.08	168.09	15.74
product 6	19.93	55.01	59.69	134.64	11.92
product 7	29.69	59.22	104.47	193.38	20.04
product 8	28.17	65.76	82.08	176.01	16.42
product 9	24.59	65.94	67.16	157.69	16.46
product 10	23.05	75.40	82.08	180.54	19.57

Conclusions

Summarising the outcomes of the theoretical analysis and the numerical example it can be concluded that the proposed logistics costing methodology may deliver real advantages in product cost calculation:

- the logistics costs, as indirect costs, are allocated to the products in a more exact and transparent way so the distortions due to the arbitrary allocations are reduced;
- the cost efficiency of the logistics functions within production can be calculated accurately and the possible outsourcing decisions can be backed up more thoroughly and more precisely;
- the contribution of logistics activities or performances to the total product cost can also be determined thanks to the separate and at the same time integrated logistics costing tool. This terminology indicates that the logistics related data are handled separately but the logistics cost objects are integral parts of the entire product costing system;
- the identified cause-effect chains make it possible to track and trace the causes of logistics costs and cost ratios so that the interventions aiming to rationalise the logistics business-technology processes or to enhance the capacity utilisation of logistics units can be planned and executed more effectively.

Nevertheless, the model presented is not perfect; it still has methodological constraints:

- simplifications may be necessary when depicting the operational structure of the examined company;
- the separation of logistics-related cost and performance data may not always be completed entirely;
- the selection of cost drivers may lead to choosing the measurable and more simple indicators instead of the more appropriate but less measurable indicators. It shall be noted that the selection of cost drivers relies mainly on the subjective decisions of the experts as the applicability of mathematical approaches is usually limited;
- the distribution of performance consumption, i.e. some of the performance intensities may not be measured exactly and estimations shall be used instead.

There are several extra conditions of the implementation, such as the availability of the input data of appropriate quality, which may require additional data collection and extensive data processing. The utilisation of a dedicated information system supported by automated data processing is the best solution, as far as it is possible. Ensuring these conditions may, however, require considerable efforts and resources.

In spite of the constraints mentioned above, the calculated cost data are still more accurate than those of traditional costing regimes. Moreover, additional information are also delivered like the detailed indicators of logistics cost efficiency or the ratio of logistics costs, etc. That is why one has to consider the advantages and the resources (costs) of the implementation, as well as the acceptable level of methodological constraints before making a decision about the introduction of the improved logistics costing system.

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