Calculation of Total Costs of Reciprocally Conditioned Service Departments – Allocation Methods

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Abstract. *This paper deals with cost assignment for indirect costs, as part of company's internal accounting structure. More often than not, there is a considerable amount of activities exchanged between various service departments, which provide services reciprocally, and not only for production departments. Consequently, when such interactions occur, it is necessary to calculate the total costs of these service departments, i.e. to determine their respective overheads. Based on an actual commercial accounting software application, a variant of the method of reciprocal allocation, namely the method of repeated addition with inclusion, is illustrated, in order to better demonstrate the theoretical and practical aspects of inter-service cost allocation*

Keywords. cost centres, indirect costs, cost allocations, service department costs, allocation methods

1 Introduction

The subject of this paper is the calculation of secondary costs as part of the cost centers calculation within management accounting of a manufacturing company. Preceding cost centres, or so called secondary cost centers, with their services in practice ultimately enable the functioning of the major, i.e., the final cost centers, but also other ancillary cost centers. Precisely this is why before the final transfer of costs from the service to the major cost centers we need to calculate the internal effects of preceding cost centres, i.e., to calculate the secondary costs.

In the preparation and drafting of this paper, different sources and literature were used, as well as data from actual commercial accounting software applications with appropriate illustrations of cost calculation in a manufacturing company, in order to better present the theoretical aspects of calculating secondary costs and its practical application. In the introductory part of the paper, the necessity of calculating the secondary costs is explained, as part of an internal calculation - the cost centers calculation. Then, in the section called *Determining total cost of ancillary and non-production cost centers* there comes an extensive theoretical representation of secondary costs. The process of determining the total cost of ancillary and non-productive cost centers is investigated, which stands for the central part of the calculation of secondary costs. Tabular and graphical illustrations are used to give examples of different approaches to this calculation, such as: 1) reciprocal allocation method, 2) iterative method of distribution, 3) the sequential allocation and 4) the method of direct allocation

2 Determining total cost of ancillary and non-production cost centers

Production overheads have always been, especially in modern highly automated production, the biggest problem for capturing and distributing on the major cost centers and cost holders (products, services, projects, programs, etc.). The problem in today enterprises is emphasized by the larger share of overheads in the cost structure of enterprises compared to direct costs [4, 2]. Non-production and service cost centers in their reciprocal relations can be influenced differently. In other words, some of the cost centers (CC) can be fully conditioned, i.e., at the same time to give and receive the services of other

CC, incomplete or conditional, i.e., only to provide services to other CC or to receive services only from certain CC. However, it is usually mixed case condition, where one CC as compared to other CC is incomplete, and in relation to some other entirely conditional. Depending on whether the CC is such that it does not consume the internal effects of other ancillary cost centers, (in which case, for them there are no secondary costs, so their primary and total costs can be immediately allocated to production CC, or CC is not fully conditioned, or a complete reciprocal conditionality), some authors recommend that the calculation of the secondary costs should be performed in stages. It means along the lines from the easy to the difficult, i.e. first to do the calculation of all those CC for which we can with certainty determine the total costs and then to address the calculation of total costs for those CC which are fully conditioned [6, 29]. [5, 81].

To allocate costs of service and non-production CC four different methods are used, the first of which can be realized in two variants [1, 116]:

1. reciprocal allocation method,
   a. simultaneous equation method,
   b. repeated addition with inclusion,
2. repeated distribution method,
3. specified order of closing method – sequential allocation method and
4. direct allocation method [3, 109].

Software solutions have different partly integrated approaches mentioned above [7], [8].

As an illustration of calculating the total cost of a fully conditioned CC, we can take a company that has three manufacturing and three service CC. The analysis of indirect costs resulted in the following allocation of the total costs (table 1.):

Table 1. Total costs of company

		(Kn)
Production departments (PD)	PD1	1.188
	PD2	2.470
	PD3	772
Service departments (SD)	SD1	300
	SD2	890
	SD3	280
	TOTAL:	5.900

Service department costs are allocated in the following manner (table 2):

Table 2. Service departments cost allocation

	Production departments			Service departments		
	PD1	PD2	PD3	SD1	SD2	SD3
SD1	31%	28%	17%	-	10%	14%
SD2	39%	24%	7%	25%	-	5%
SD3	33%	33%	23%	2%	9%	-

2.1 Reciprocal allocation method

Reciprocal allocation method takes into account the mutual interaction between different service cost centers. Using this method, regardless of which variant of its realization is done, the overall costs of non-productive and services cost centers are established in the first place, and then, according to pre-defined keys, they are moved to the final cost centers.

2.1.1. Linear equations method

When using this method, a system of linear equations is set as follows:

x = total indirect costs SD1

y = total indirect costs SD2

z = total indirect costs SD3

Total costs transferred to SD1, SD2 and SD3, according to the scheme shown in Table 2, can be represented as follows:

$$x = 300 + 0.25y + 0.02z$$

$$y = 890 + 0.1x + 0.09z$$

$$z = 280 + 0.14x + 0.05y$$

The solution of the system of equations is obtained with the following values (rounded to two decimal places):

$$x = 553{,}62;\ y = 981{,}94;\ z = 406{,}60$$

Having calculated the values of x, y and z, it is possible, according to the given key, to allocate the total cost of the service cost centers to the other CC, and so to get the total costs of the final cost centers, as illustrated in Table 3:

Table 3. Total costs

		PD1	PD2	PD3	Total
1	Primary costs	1,188.00	2,470.00	772,00	4.430.00
2	Allocation SD1	171.62 (31%)	155.02 (28%)	94.18 (17%)	420.83
3	Allocation SD2	382.96 (39%)	235.66 (24%)	68.73 (7%)	687.37
4	Allocation SD3	134.17 (33%)	134.17 (33%)	93.52 (23%)	361.88
5	Total:	1876,77	2994,87	1028,44	5.900,00

2.1.2 Repeated addition with inclusion method

The basis for calculating the total costs of service cost centers are their already known costs, and this is the mass of their primary costs. The total cost of each cost center comes from the sum of its primary costs and the additions, which are iteratively calculated according to the allocation key of the individual cost centers on the respective recipients of services. In order to execute the calculation according to this method, it is necessary to make a table (see Table 4) in which the columns represent the service cost centers, with their respective primary costs in the first line, which are the starting point for the calculation of total costs.

The calculation of the *first* addition for the service cost center located in the first column is carried out by applying the relative percentages of participation to the amount of the primary costs of those cost centers which services it receives. The first addition for the cost centers in the second and further position in the table is calculated by applying the respective percentages of participation in the expenditure of services provided by the cost centers positioned to the left, by suming their primary costs and already calculated first supplement of these cost centers. The percentages of participation in the expenditure of services provided by the cost centers situated to the right are only applied to the primary costs of these cost centers.

Table 4. Repeated addition with inclusion method

	Service departments			Total
	SD1	SD2	SD3	
0	300,00	890,00	280,00	1.470,00
1	228,10	78,01	122,33	
2	21,95	13,21	3,73	
3	3,38	0,67	0,51	
4	0,18	0,06	0,03	
5	0,02	0,00	0,00	
6	0,00	0,00	0,00	
8	553,63	981,95	406,60	1.942,18
9	420,76 (0,76)	687,37 (0,70)	361,87 (0,89)	1.470,00

The *second* addition for the cost center in the first position in the column is calculated by applying the appropriate percentages of the amounts calculated for the first additions of those cost centers which services it consumes. For a cost center in the second column, and all other cost centers, the *second* addition is calculated on the basis of the respective percentages of participation in the expenditure of services positioned to the left of the cost center, calculated from their already known second addition. Percentage shares of services consumption of the cost centers situated the right of these cost centers are calculated from the amount of the first addition of these cost centers. Third, like all other additions are calculated analogous to the second addition.

Iterations with the inclusion of the additions are repeated until they become so small that they can be ignored. To get the total cost for each cost center, the calculated additions should be added up to the primary costs, as illustrated in Table 4.

As noted, using the method of additions with inclusion identical results are obtained as with the method of linear equations. After the values of total costs by cost centers are calculated, in a second step, according to the given allocation key, the total cost of the service cost centers are allocated to other cost centers, and thus we get the total cost of the final cost centers, as illustrated in Table 3 in the previous section where the method of linear equations is discussed.

Figures 1-8 show an example of calculating the total cost of non-production and service cost centers as part of a practical accounting software application. Figure 1 represents an adjusted view (via query to the database - the table which holds records of internal services) of internal services with their volume component. In the first column, the cost centers of the service givers (represented by codes 04, 05 and 06) are sorted, the second column holds the service recipients, the third column contains the unit of measure in which the effects are expressed, while the last column relates to the quantitative component (expressed in hours) of internal effects.

MT1	MT2	JM	Kol
04	01	h	31
04	02	h	28
04	03	h	17
04	05	h	10
04	06	h	14
05	01	h	39
05	02	h	24
05	03	h	7
05	04	h	25
05	06	h	5
06	01	h	33
06	02	h	33
06	03	h	23
06	04	h	2
06	05	h	9

Figure1. An overview of internal services with their quantitative component

On the basis of concrete records in the aforementioned application, using an action query, a temporary table of a structure shown in Figure 2 is created. The Table is created anew each time when starting the program procedure for calculating the secondary costs, since it is deleted at the end of the procedure. The point of creating the temporary table is to obtain a structure

where it will be possible to temporarily store the calculated data for the convenience of finding out the value of additions calculated through iterations and the sum of total costs. Then the records in the table are arranged in ascending order of column 6 (the cost centers that take services), and then by column 3 (service providers), as illustrated in Figure 3.

Field Name	Data Type	
idprometinterneusluge	AutoNumber	1
idperiodaobracuna	Number	2
siframjestatroska1	Text	3
primarnitrosakmjestatroska1	Number	4
ukupnitrosakmjestatroska1	Number	5
siframjestatroska2	Text	6
primarnitrosakmjestatroska2	Number	7
ukupnitrosakmjestatroska2	Number	8
jedinicamjere	Text	9
kolicina	Number	10
vrijednost	Number	11
procenatucesca	Number	12
dodatak	Number	13

Figure 2. Design of the table with internal services transactions

1	2	3	4	5	6	7	8	9	10	11	12	13
2896	40	05	890	0	04	300	0	h	25	0	25	0,00
2901	40	06	280	0	04	300	0	h	2	0	2	0,00
2891	40	04	300	0	05	890	0	h	10	0	10	0,00
2902	40	06	280	0	05	890	0	h	9	0	9	0,00
2892	40	04	300	0	06	280	0	h	14	0	14	0,00
2897	40	05	890	0	06	280	0	h	5	0	5	0,00
(New)												

Figure 3. Table with internal services transactions

Besides the aforementioned table, two arrays are declared in the procedure: the first, NizCCPrimaoci, one-dimensional, where the codes of the cost centers recipients of internal services are held and 2) NizPromet, which is two-dimensional, where the first dimension is used to refer to the codes of the cost centers, and the other to the storage of the respective additions calculated through iterations. The first array is shown in Figure 4, while the second array can be seen in Figure 6.

```
Immediate
 ?NizMTPrimaoci(0) & " | " & NizMTPrimaoci(1)& " | " & NizMTPrimaoci(2)
 04 | 05 | 06
```

Figure 4. Array with the codes of the cost centers that take services

As iterations progress, so in the immediate window (the programming language Visual Basic for Applications - VBA), an alphanumeric string with concatenated values of two-dimensional array is printed. So, for example, the expression NizPromet(0.0) represents the value of 300, i.e. the value of the primary cost of the cost center in the first position (zero position, as it is a zero based array), NizPromet(1,0) = 890, i.e. the primary expense of the second (CC05) cost center and NizPromet(2,0) = 280, i.e. the primary cost of the third service cost center (CC06). The next iteration outputs the calculated first addition, followed by the second and so forth until the additions become negligible.

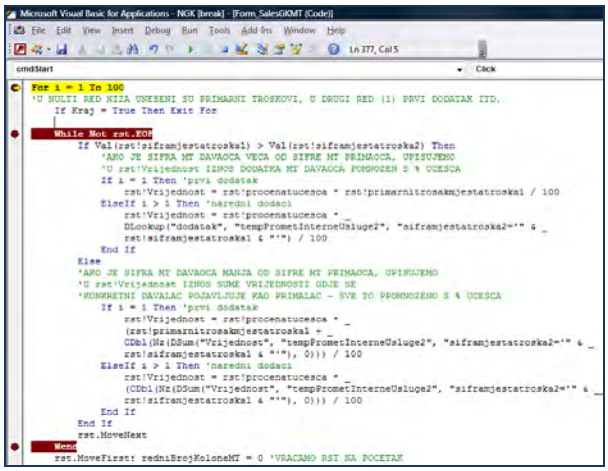

Figure 5. Loop for calculating additions as part of a VBA programming procedure

Figure 5 shows part of the code of the programming procedure for calculating the secondary costs, specifically the one with the logic of calculating the first and all subsequent additions. When the records from the table with transactions of internal services are sorted as previously presented (Fig. 3), a recordset is declared and opened, which is passed through by means of a loop shown in Figure 5. While passing through the recordset, a comparison is made: if the code of a service cost center is greater than the code of the cost center that takes services, then the field *rst!Vrijednost* will get the multiplication of the percentage of participation and calculated addition from the previous iteration in the table where the service provider appears as the recipient. If the code of the service provider is less than the code of the recipient cost center (analogous to previously described method where the cost center is placed to the left of the service recipient cost center), then the participation percentage is multiplied by the sum of the values which already includes the addition of the current iteration. As the cursor passes through the recordset, so the value of additions are inserted into NizPromet, which will be repeated through several iterations, until the values of supplements dwindle to zero, as illustrated in Figure 6. When the values of additions decrease to zero, the program comes out of the so-called *for loop*, after which, in a separate procedure, primary costs and all additions are summed up by cost centers, thus obtaining the total costs by cost centers.

```
Immediate
 ?NizPromet(0,0) & " | " & NizPromet(1,0) & " | " & NizPromet(2,0)
300 | 890 | 280
 ?NizPromet(0,1) & " | " & NizPromet(1,1) & " | " & NizPromet(2,1)
228,1 | 78,01 | 122,33
 ?NizPromet(0,2) & " | " & NizPromet(1,2) & " | " & NizPromet(2,2)
21,95 | 13,21 | 3,73
 ?NizPromet(0,3) & " | " & NizPromet(1,3) & " | " & NizPromet(2,3)
3,38 | 0,67 | 0,51
 ?NizPromet(0,4) & " | " & NizPromet(1,4) & " | " & NizPromet(2,4)
0,18 | 0,06 | 0,03
 ?NizPromet(0,5) & " | " & NizPromet(1,5) & " | " & NizPromet(2,5)
0,02 | 0 | 0
 ?NizPromet(0,6) & " | " & NizPromet(1,6) & " | " & NizPromet(2,6)
 0 | 0 | 0
```

Figure 6. Illustration of the primary costs and additions in the immediate window

Figures 7 and 8 show part of the program code where, upon completion of the calculation of total costs by cost centers, records of transactions of internal services are updated for a certain period of time, namely, the data related to the total costs for each cost center are entered. In addition, the prices of internal services by cost centers are updated, which can now, the total costs having been defined, be easily calculated by dividing the total costs by the sum of the effects any particular cost center provides to others in terms of internal services.

```
i = 0: j = 0
For i = 0 To brojMjestaTroskovaLong - 1 'IZRACUN I UPIS U NIZ NAREDNIH DODATAKA
    For j = 0 To brojIteracijaLong - 1
        sumaVrijednostiUNizu = sumaVrijednostiUNizu + CDbl(NizPromet(i, j))
    Next j

    Call AzurirajUkupneTroskoveMT1(Me.IDPeriodaObracuna, NizMTPrimaoci(i), sumaVrijednostiUNizu)
    Call AzurirajUkupneTroskoveMT2(Me.IDPeriodaObracuna, NizMTPrimaoci(i), sumaVrijednostiUNizu)

    sumaVrijednostiUNizu = 0
Next i

Call AzurirajCijeneInternihUsluga(Me.IDPeriodaObracuna)

Me.lblObavjestenje.Caption = "Gotovo!"
```

Figure 7. Part of the programming code for up dating the total costs and the prices of interna l services

The procedure shown in Figure 8 consists of a simple update SQL query, to which we pass three arguments: the period of calculation, the code of the cost center and the value of its total costs. Similar procedure is used to update the total costs of givers and takers of internal services.

After the total costs by cost centers are calculated, the total costs of the service cost centers are allocated to other cost centers according to a given key, and thus we determine the total costs of the final cost centers - analogous to previously described method, illustrated in Table 3.

```
Sub AzurirajUkupneTroskoveMT1(periodObracuna As Long, sifraMT1$, sumaVrijednostiUNizu)
On Error GoTo ErrorHandler
Dim strSQL As String

strSQL = "UPDATE prometinterneusluge SET prometinterneusluge.vremenskipecat = '" & Timer() & _
"', prometinterneusluge.ukupnitroskmjestatroska1 = '" & sumaVrijednostiUNizu & "' " & _
"WHERE (((prometinterneusluge.idperiodaobracuna)=" & periodObracuna & _
") AND ((prometinterneusluge.siframjestatroska1)='" & sifraMT1 & "'));"
DoCmd.RunSQL strSQL

ExitSub:
    Exit Sub
ErrorHandler:
    MyMsgBox Err.Description, vbInformation, "Greska!"
    Resume ExitSub
End Sub
```

Figure 8. Procedure with a SQL query for upd ating the total costs of internal services

2.2 Repeated distribution method

When using this method, the costs of service departments are repetitively allocated in a certain percentage to other cost centers, until the digits become negligibly small. Unlike the previously described methods, this method does not perform the previous calculation of only service and non-productive cost centers, and then the allocation of costs from them to the final cost centers, i.e. the production cost centers, but the costs are allocated in turn to all the other cost centers. The second row of table 5 shows that the costs of SD1 are allocated to all other cost centers in proportion to a given percentage. As a result, a part of costs of SD1 is transferred to SD2 and SD3. In the third row, the costs of SD2 are distributed, meaning that SD1 and SD3 receive additional charges. The procedure is repeated for the third cost center - SD3. Then, in the next iteration, the costs of SD1 are re-allocated, allowing SD2 and SD3 to receive additional charges. This process continues until the line 14, where the costs become so small that any further allocation is unnecessary. At the end, the total costs, presented in row 14 by the amount of 5900 money units, are transferred to the production departments.

2.3 Sequential allocation method

Using this method, the costs of service departments are allocated to the production departments in a specific order. As usual, the service department performing the most work for other service cost centers will be closed first, then follows the second cost center by the same criteria, and so on. Return costs are not passed on to the service departments, which costs were previously allocated. It is noticeable that the total value of the costs by cost centers do not coincide with the values of the total costs obtained by previously illustrated two methods (inclusion of additions and linear equations). This is because the method of closing by a specified order sacrifices accuracy on behalf of the simplicity of calculation. However, if this method provides an approximate result as the previous two, more precise methods, then there are legitimate reasons for its practical application.

2.4 Direct allocation method

The method of direct allocation ignores the mutual reciprocal allocation of costs between service cost centers. Accordingly, the costs of service departments are transferred only to the production, i.e., the final cost centers. This simple method can be applied in cases where the intensity of reciprocal services between service and non-productive cost centers is relatively small.

the calculation of secondary costs is in place, we can summarize as follows:

Table 6. Illustration of distribution method

		PD1		PD2		PD3		SD1		SD2		SD3		
1	**P. T.**		1188		2470		772		300		890		280	5900
2	**SD1**	0,31	93	0,28	84	0,17	51	-	-300	0,10	30	0,14	42	
3	**SD2**	0,39	359	0,24	221	0,07	64	0,25	230	-	-920	0,05	46	
4	**SD3**	0,33	121	0,33	121	0,23	85	0,02	7	0,09	33	-	-368	
5	**SD1**	0,31	74	0,28	67	0,17	40	-	-238	0,10	24	0,14	33	
6	**SD2**	0,39	22	0,24	14	0,07	4	0,25	14	-	-57	0,05	3	
7	**SD3**	0,33	12	0,33	12	0,23	8	0,02	1	0,09	3	-	-36	
8	**SD1**	0,31	5	0,28	4	0,17	3	-	-15	0,10	1	0,14	2	
9	**SD2**	0,39	2	0,24	1	0,07	0	0,25	1	-	-5	0,05	0	
10	**SD3**	0,33	1	0,33	1	0,23	1	0,02	0	0,09	0	-	-2	
11	**SD1**	0,31	0	0,28	0	0,17	0	-	-1	0,10	0	0,14	0	
12	**SD2**	0,39	0	0,24	0	0,07	0	0,25	0	-	0	0,05	0	
13	**SD3**	0,33	0	0,33	0	0,23	0	0,02	0	0,09	0	-	0	
14	**Total**		1877		2995		1028		0		0		0	5900

Table 7. Specified order of closing method

	Production departments						**Service departments**						**Total**
	PD1		PD2		PD3		SD3		SD1		SD2		
P. T.		1188,00		2470,00		772,00		280,00		300,00		890,00	5900
SD2	0,39	347,10	0,24	213,60	0,07	62,30	0,05	44,50	0,25	222,50	-	-890	
SD1	0,31 0,90	179,97	0,28 0,90	162,56	0,17 0,90	98,69	0,14 0,90	81,28	-	-522,50	-0,1		
SD3	0,33 0,89	150,46	0,33 0,89	150,46	0,23 0,89	104,86	-	-405,78	0,02		-0,09		
Total:		1865,53		2996,61		1037,86							5900

Table 8. Direct allocation method

	Production departments						**Service departments**						**Total**
	PD1		PD2		PD3		SD3		SD1		SD2		
P. T.		1188,00		2470,00		772,00		280,00		300,00		890,00	5900
SD3	0,33 0,89	103,82	0,30 0,89	103,82	0,23 0,89	72,36	-	-280	0,02		-0,09		
SD1	0,31 0,76	122,37	0,28 0,76	110,53	0,17 0,76	67,11	0,14		-	-300	-0,1		
SD2	0,39 0,70	495,86	0,24 0,70	305,14	0,07 0,70	89,00	0,05		0,25		-	-890	
Total:		1910,05		2989,49		1000,46							5900

2.5 Processing of secondary costs

After we perform the calculation of total secondary costs, it is necessary to perform their processing, which is possible in two ways, depending on how the internal cost calculation is organized: 1) accounting method, based on the chart of accounts or the 2) statistical, or so-called production calculation sheet (POL). Details of this phase of the internal cost calculation exceed the interest of this work, but after

- The accounts of preceding cost centers are closed after the calculation of secondary costs has been done. There is no balance on the accounts, but the traces of their total costs remain, which is of a great informative value.
- All the general expenses are transfered, except those that are treated as expenses of the company as a whole, to the final cost centers, which is the prerequisite to make a calculation of the price of

the services of all the cost centers and, ultimately, to transfer the costs to the final products.

3. Conclusion

Calculation of secondary costs plays a very important role in the internal accounting of those companies where there is a strong reciprocal conditioning of non-productive and service cost centers. The accuracy of calculation of the secondary costs determines the cost of certain types of internal services, which ultimately determines the accuracy of calculating the total cost of the final cost centers to which all the costs from the preceding cost centers are transfered. To determine the total costs of ancillary and non-productive cost centers two methods which ensure complete accuracy (method of linear equations and method of additions with inclusion) are used, while the other two methods (specified order of closing and the method of direct allocation) do not lead to a completely accurate allocation of costs to the final, production cost centers, but which, for reasons of simplicity, where conditions allow, can be applied without significant distortion of the accuracy of the final allocation of costs by cost centers.

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