Complex Cost Allocation Problems And Contemporary Electronic Spreadsheet Technology

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Abstract

Despite the observation that the reciprocal method produces more accurate service department cost allocations, many cost accounting textbooks continue to emphasize the direct method and the step method. Similarly, the direct method and the step method appear to be the dominant approaches used in practice. It has been conjectured that these methods are popular because they are easier to apply. This paper uses an easy-to-use optimizer included in electronic spreadsheets to make the case that ease of use may no longer be an acceptable reason for under-emphasizing the reciprocal method in cost and management accounting textbooks. The paper shows how complex cost allocation problems may be solved without reliance on matrix algebra as proposed by several authors, including Williams and Griffin (1964), Churchill (1964), Livingstone (1968), Jacobs and Marshall (1987), Brown and Killough (1988), and Jennings and Day (1997). The proposed approach does not result in a circular error, which one encounters when using the techniques recommended by Savage and Wilburn (1997) and Burch (1994). Although a circular error may not necessarily produce incorrect results, spreadsheet software developers, such as Lotus, MicroSoft, and Corel caution that the risks of incorrect results are high and that they do not guarantee the accuracy of the calculations when a circular error exists in a template.

Introduction

Issues relating to the allocation of indirect costs have been debated in the accounting literature for at least four decades. Critics of indirect cost allocations, such as Thomas (1969, 1974), claim that cost allocations are arbitrary and can result in poor decisions. Despite this and other criticisms, cost allocations are important in financial, as well as management accounting (Fremgen and Liao, 1981; Atkinson, 1987), and many cost and management accounting textbooks devote at least one chapter to indirect cost allocations. If one includes the recent rise in popularity of activity-based costing and the contemporary emphasis on accurate cost measurement, a substantial portion of the management accounting literature is devoted to indirect cost allocation issues. Much of that discussion surrounds the methods used to allocate or assign costs from service departments (or resource centers) to production centers (or activity centers).

Readers with comments or questions are encouraged to contact the authors via e-mail.

Methods used to allocate costs incurred by service departments have been extensively covered in cost accounting literature. The objective is typically to allocate costs from multiple service departments to production centers. Service departments often provide services to many production centers, as well as to other service departments. Most cost and management accounting textbooks include discussion on three methods for allocating service department costs--a direct method, a step method, and a reciprocal method. The direct method allocates service department costs by ignoring all inter-service department support services. The step method improves the process used to allocate service department costs, but does so only partially. Under this method, which allocates cost through a series of steps, the inter-service department support services of the first service department in the process are recognized in the allocation process. However, subsequent steps ignore some or all of the inter-service department support services. Both the direct and step methods produce questionable allocations (Brown and Killough, 1988). The reciprocal method, which takes into consideration all inter-service department support services, is more comprehensive and produces more accurate allocations (Jacobs and Marshall, 1987; Brown and Killough, 1988; Horngren, Foster and Datar, 2000).

Despite the observation that the reciprocal method produces more accurate cost allocations, many cost accounting textbooks continue to emphasize the direct method and the step method. Similarly, the direct method and the step method appear to be the dominant approaches used in practice (Jacobs and Marshall, 1987; Jennings and Day, 1997; Horngren, Sundem, and Stratton, 1996). It has been conjectured that these methods are popular because they are easier to apply than the reciprocal method (Jacobs and Marshall, 1987; Horngren et al., 1996; Jennings and Day, 1997; and Savage and Wilburn, 1997). This paper uses an easy-to-use optimizer included in many electronic spreadsheets to make the case that ease of use may no longer be an acceptable reason for stressing the direct and step methods and under-emphasizing the reciprocal method in cost accounting textbooks. The paper shows how complex cost allocation problems may be solved without reliance on matrix algebra as proposed by several authors (Williams and Griffin, 1964; Churchill, 1964; Livingstone, 1968; Brown and Killough, 1988; Jacobs and Marshall, 1987; Jennings and Day, 1997). The proposed approach also does not result in a circular error, which one encounters when using the technique proposed by Savage and Wilburn (1997) and Burch (1994). Although a circular error may not necessarily produce incorrect results, spreadsheet software developers, such as Lotus, MicroSoft, and Corel caution that the risks of incorrect results are high and that they do not guarantee the accuracy of the calculations when a circular error exists in a template.

The remainder of the paper is organized into three sections. The next section reviews the relevant literature on methods and techniques for applying the reciprocal method of service department cost allocations and outlines the limitations of prior attempts to use electronic spreadsheet technology in applying the reciprocal method. A subsequent section discusses and illustrates the use of electronic spreadsheet optimizers in applying the reciprocal method. The final section summarizes and concludes the paper.

Prior Literature

Despite some debate about the form of the model, simultaneous equations and matrix algebra have long been proposed as a general approach for applying the reciprocal method of cost allocation. For example, Williams and Griffin (1964) expressed the cost allocation problem in terms of a system of algebraic equations. They observed (p. 672) that a simultaneous equation solution is "the most efficient solution form" when the cost allocation equation is relatively simple and contains only a few variables. However, Williams and Griffin (1964), as well as

Churchill (1964), proposed matrix algebra as a more general approach for solving the cost allocation problem in situations where the system of cost allocation equations is complex and contains several variables and equations. The general solution proposed by these authors, specified in terms of matrix algebra, is as follows:

$$x = A^{-1}b \quad (1)$$

where,

> x = a vector made up of elements x_i, ($i=1 \ldots n$), with x_i representing the redistributed cost of service department i after costs are allocated from other service departments;
>
> A^{-1} = the inverse of a square matrix containing the service departments' allocation percentages; and
>
> b = a vector made up of elements b_i, ($i=1 \ldots n$), with b_i representing the direct costs of service department i.

While not disputing the use of matrix algebra as a technique for solving complex cost allocation problems, Manes (1965) criticized the general solution described above because the sum of the redistributed service department costs ($3x_i$) exceeds the sum of the direct costs incurred by service departments ($3b_i$). This implies that the marginal cost of operating a service department is not equal to the redistributed cost (x_i) allocated to that department. Manes (1965), therefore, proposed an alternative solution that reduces x_i by the proportion of the cost that department i incurs to support other service departments. Livingstone (1968), however, observed that Manes' solution contained an error in the modified allocation proportions and demonstrated that the Manes (1965) model and the Williams and Griffin (1964) model produce equivalent results. The two models allocate identical costs to production departments.

Jacobs and Marshall (1987) and Jacobs, Marshall, and Smith (1993) present what they described as a simple approach to allocating service department costs that approximate the accuracy of the reciprocal method. They observed that the reciprocal method could be approximated as follows:

$$X = b + \lambda.r \quad (2)$$

where:

> X = a vector of allocated costs to n production departments, ($n = 1 \ldots N$), and the amount allocated to each production department is represented as x_n.
>
> b = a vector of direct costs incurred in service department j, ($j = 1 \ldots J$), and the direct cost associated with each service department is represented as b_j.
>
> r = a vector representing the total proportion of service provided by service department j, ($j = 1 \ldots J$), and the total proportion of service provided by each service department to all service departments is represented as r_j.
>
> $\lambda = [\{(\Sigma b_i)/J\} \,/\, (1 - \alpha)]$, i.e., average direct costs per service department $\{(\Sigma b_i)/J\}$ divided by $(1 - \alpha)$; α is the average proportion of service department service consumed by service departments—i.e., $\alpha = [(\Sigma r_i)/J]$.

Although this method appears to be intuitive, it has not appeared in textbooks and there is no evidence that it has been adopted in practice. Moreover, Jacobs and Marshall (1987) acknowledge that their method approximates the reciprocal method only in situations where the service departments are relatively homogeneous with respect to traceable costs and the amount of service provided to service departments. These restrictive conditions make it doubtful that the authors' proposal would produce accurate allocations if used in practice.

Baker and Taylor (1979) proposed a linear programming framework to allocate service department costs to production centers when reciprocal services exist between service centers. Unlike the rest of the literature which seek to allocate service center costs based on the volume of services consumed, Baker and Taylor (1979) determined the optimal volume of service that must be provided by each service department in order to minimize total service department costs. Their model is based on the technological relationships that exist between pairs of service departments, an *a priori* cost per unit in each production center, and an output volume in each production department. While Baker and Taylor (1979) indicate that their linear programming model may be used for cost allocations, it is proposed primarily as a framework for evaluating make-buy decisions in situations where reciprocal services exist. Nonetheless, it is important to note that their model and assumptions reverse the normal sequence in which product costs are accumulated. This makes it inappropriate for solving the typical service department cost allocation problem.

Use of computer technology

The reciprocal method of allocating service department costs requires the manipulation of complex linear equations. This is a difficult task, particularly when there are more than three service departments involved. Computer technology is often a necessity in solving such problems. Early researchers, such as Williams and Griffin (1964), Manes (1965), and Livingstone (1968), used complex main frame computer technology to solve a cost allocation problem that involved as few as five service departments. More recently, Brown and Killough (1988), Pirrong and Bain (1989), Burch (1994), Jennings and Day (1997) and Savage and Wilburn (1997) have all demonstrated that low cost micro computer technology and user-friendly electronic spreadsheets make the reciprocal method relatively easy to apply.

Brown and Killough (1988) showed how Lotus 1-2-3 (release 2) may be employed to invert and multiply matrices in solving for the x vector in the reciprocal cost allocation model, $x = A^{-1}b$. Similarly, Jennings and Day (1997) employed Corel Quattro Pro (version 7) to invert and multiply matrices in applying the reciprocal method. While matrix operations are relatively easy to apply when using electronic spreadsheets, one needs at least an elementary knowledge of matrix algebra in order to employ the tools used by Brown and Killough (1988) and Jennings and Day (1997) in a meaningful way.

Burch (1994) employed an intuitive spreadsheet-based technique to solve the reciprocal cost allocation problem. However, his approach results in a circular error. A circular error results when a formula entered in a cell uses its own cell as part of the formula. Circular references are problematic in electronic spreadsheets because a template that includes a circular reference is not guaranteed to be accurate. Burch (1994), replicated by Savage and Wilburn (1997), computes a department's redistributed service department costs after allocations from other service departments (x_i) by using the following expression:

$$x_i = b_i + \Sigma a_{ij} x_j \qquad \text{(3)}$$

where,

b_i = the direct cost of service department i, (i = 1, 2, 3, . . . n);

a_{ij} = the proportion of service activity that service department i uses from service department j, (j = 1, 2, 3, . . . n); and

x_j = redistributed service department costs for department j after costs are allocated from other service departments.

Thus, the redistributed service department costs for Department 1 after costs are allocated from other service departments would be:

$$x_1 = b_1 + a_{11}x_1 + a_{12}x_2 + a_{13}x_3 + \ldots\ldots + a_{1n}x_n \quad \ldots\ldots\ldots\ldots\ldots (4)$$

Burch (1994) computes each x_i in a single cell in an electronic spreadsheet. This produces a circular reference because, as seen in equation (3), x_1 appears on both sides of the equation, implying that the formula used to compute x_1 references the cell in which the formula is located. Because expression (3) produces a circular error when applied in an electronic spreadsheet, Burch (1994) and Savage and Wilburn (1997) recommend that the circular reference must be solved by hitting the F9 key (i.e., the recalculation key) until there is no change in the resulting reciprocal costs. This sometimes requires the student to change the default number of iterations that spreadsheet employs in completing complex computations.

Pirrong and Bain (1989) noted that effective structuring of the reciprocal cost allocation problem makes it easy to solve. They used an iterative process that repetitively allocated the direct costs incurred by service departments to production departments until there were no costs left in any of the service departments. Though this method is relatively simple to apply, each iteration begins by copying formulae from the prior iteration and pasting them to the new iteration. Pirrong and Bain (1989) used eleven such iterations to solve a simple problem with three service departments and two production departments. Problems that involve more service departments would require more iterations, a process which could become cumbersome and unwieldy.

In summary, prior attempts to use computer technology to apply the reciprocal method of allocating service department costs may be criticized for the following reasons:

1. they require manipulation of complex linear equations (Williams and Griffin, 1964; Churchill, 1964; Manes, 1965; Livingstone, 1968; Jennings and Day, 1997);
2. they employ matrix operations, requiring that students and practitioners have a fundamental understanding of matrix algebra in order to solve complex cost allocation problems (Brown and Killough, 1988; Jennings and Day, 1997);
3. they employ procedures that result in circular errors, which may produce inaccurate results (Burch, 1994; Savage and Wilburn, 1997); and
4. they employ iterative methods that require students and practitioners to copy and paste formulae repetitively, which becomes cumbersome and unwieldy as the number of service departments increases (Pirrong and Bain, 1989).

Electronic Spreadsheet Optimizers

Spreadsheet optimizers, such as MS Excel's Solver or Corel Quattro Pro's Optimizer, can respond very effectively to most of the criticisms outlined in the previous section. These spreadsheet optimizers are available as part of the tools menu in both Excel and Quattro Pro and may be used to apply the reciprocal method of service cost allocation. To employ these optimizers, one must understand the logical relationships that exist between service centers, but it is not necessary to understand linear algebra or matrix operations. Application of these electronic spreadsheet tools will not produce a circular error and the model building process to apply the reciprocal method is efficient and easy to comprehend. The following problem, adapted from Williams and Griffin (1964) is used to illustrate the use of electronic spreadsheet optimizers in applying the reciprocal method of service department cost allocation:

ABC, Inc. has three activity centers, A, B, and C. These activity centers are supported by five resource centers—Resource Centers 1, 2, 3, 4, and 5. The company's accountants have identified appropriate resource drivers for each of the five departments and have used them to compute the allocation proportions shown in the following table for allocating the direct costs of resource centers to the activity centers. They plan to use the reciprocal method to allocate direct costs from resource centers to activity centers.

Either Excel's Solver or Quattro Pro's Optimizer may be used to solve ABC's reciprocal cost allocation problem. However, Excel is employed in this paper because it is more widely used in business than Quattro Pro. Excel's Solver is a powerful tool that allows analysts to solve complex problems by identifying logical relationships and simply filling out an intuitive dialogue box.

A problem may be solved using Solver if it can be modeled to include three parameters—a target cell, changing cells, and constraints.[1] First, the problem must have a single target cell that must be maximized, minimized, or set to a specific value. A cost allocation problem may be modeled so that the total service department (resource center) costs allocated to a production department (activity center) is equal to the sum of the direct costs from all service departments (resource centers).[2] In the context of the reciprocal method, the total service department cost allocated to production departments is the target value that Solver would use to find a solution. The target cell must refer to the changing cells either directly or indirectly.

Second, the target cell must contain a formula that refers to one or more *changing cells*, which Solver derives through an iterative process. Solver automatically adjusts these cells until it finds the maximum, minimum, or required value for the target cell formula. When applied to the reciprocal method, the *changing cells* would be each resource center's redistributed costs after allocations from other service departments—i.e., the equivalent of x_i in equation (1). The shaded area in Table 1 shows cell addresses (B12:F12) for the *changing cells* for ABC, Inc.'s cost allocation problem. Observe that these cells are left blank. They are, however, referenced elsewhere in modeling the problem.

Third, the solution to the problem must satisfy one or more constraints. To apply the reciprocal method, an analyst must model the redistributed costs for each resource center by referencing the redistributed costs derived iteratively by Solver in the *changing cells* (B12:F12). Referring to the cell addresses for the direct costs, the redistributed costs derived in the *changing cells*, and allocation proportions in Table 1, the redistributed cost for each resource

	Allocated to Resource Center (RC)				Activity Center (AC)			
	RC 1	RC 2	RC 3	RC 5	AC 1	AC 2	AC 3	Total
Direct Costs	$8,000	$12,000	$6,000	$13,000				
Allocated from:								
Resource Center 1	0%	0%	10%	10%	25%	25%	25%	100%
Resource Center 2	0%	0%	10%	10%	80%	0%	0%	100%
Resource Center 3	5%	10%	0%	5%	20%	30%	20%	100%
Resource Center 4	10%	5%	5%	0%	0%	40%	40%	100%
Resource Center 5	20%	20%	20%	0%	10%	5%	5%	100%

Table 1
Excerpt from an Excel Template Showing Allocation Proportions and Changing Cells

	A	B	C	D	E	F
4						
5		RC 1	RC 2	RC 3	RC 4	RC 5
6	Direct Costs	$8,000	$12,000	$6,000	$11,000	$13,000
7	Resource Center 1	0%	0%	10%	5%	10%
8	Resource Center 2	0%	0%	10%	0%	10%
9	Resource Center 3	5%	10%	0%	10%	5%
10	Resource Center 4	10%	5%	5%	0%	0%
11	Resource Center 5	20%	20%	20%	20%	0%
12	Changing Cells					

center would be modeled as follows:

Redistributed costs from RC 1 =B6+B7*B12+B8*C12+B9*D12+B10*E12+B11*F12 . . . . (5)

Redistributed costs from RC 2 =C6+C7*B12+C8*C12+C9*D12+C10*E12+C11*F12 . . . . (6)

Redistributed costs from RC 3 =D6+D7*B12+D8*C12+D9*D12+D10*E12+D11*F12 . . . . (7)

Redistributed costs from RC 4 =E6+E7*B12+E8*C12+E9*D12+E10*E12+E11*F12 . . . . . .(8)

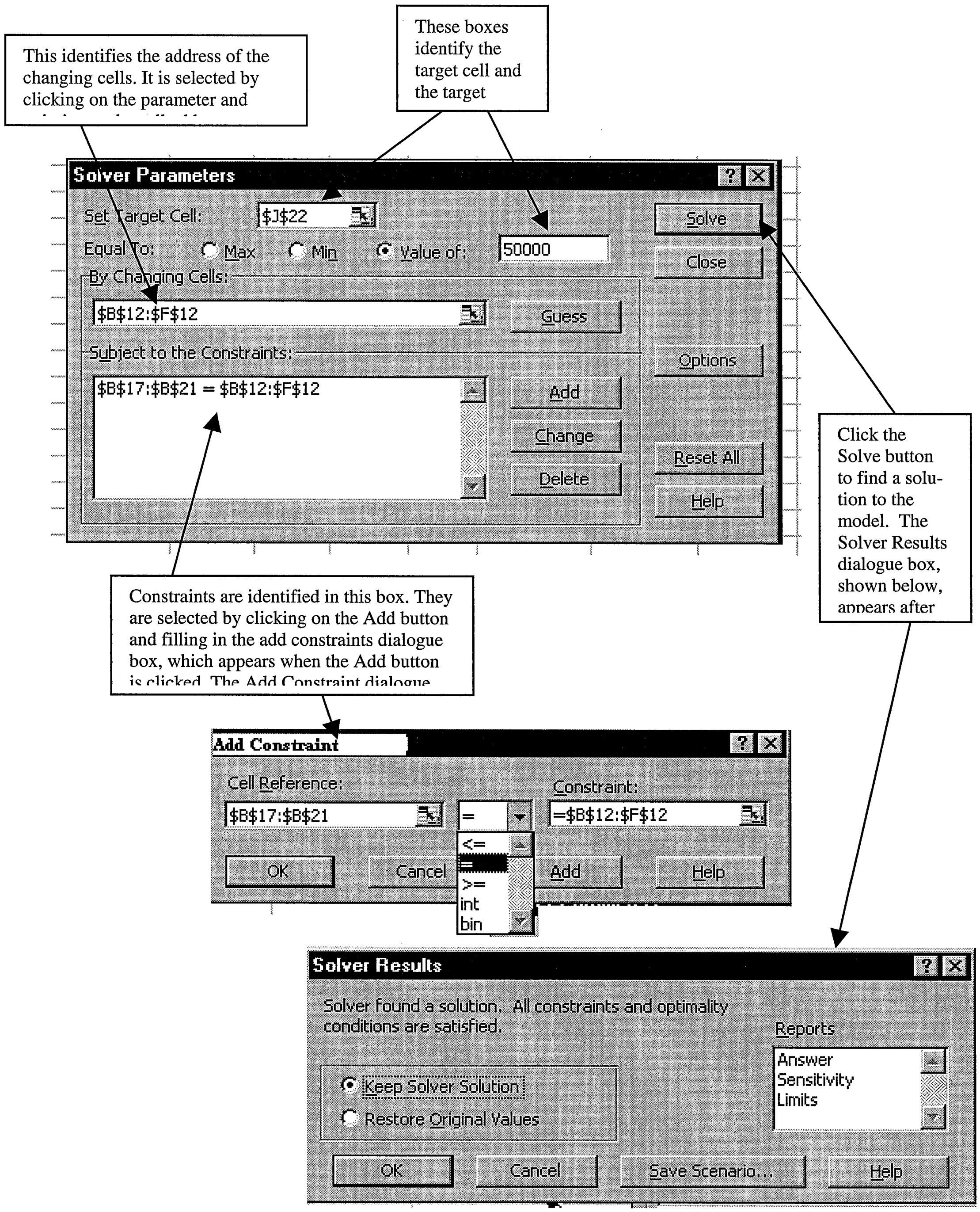
Redistributed costs from RC 5 =F6+F7*B12+F8*C12+F9*D12+F10*E12+F11*F12 . ... (9)

Constraints must be set so that Solver obtains a solution that makes the value of the redistributed cost modeled by the analyst equal to the value of the redistributed cost derived iteratively by Solver in the *changing cells*. Suppose expressions (5) to (9) are located in the range B17:B21, the constraints would be B17 = B12; B18 = C12; B19 = D12; B20 = E12; B21 = F12. This series of constraints may also be expressed as B17:B21 = B12:F12.

Identifying Solver Parameters

Once the target cell, changing cells, and constraints are modeled, the problem may be solved in Excel by selecting the Tools | Solver command to display the Solver Parameters dialogue box and by entering the relevant cell addresses in the dialogue box. Quattro Pro uses a similar dialogue box for its Optimizer. Identifying the target cell and the changing cells in the Solver Parameter dialogue box merely requires the user to select the appropriate parameters and point to the relevant cell addresses. To identify the target cell, one would click on the target cell parameter in the dialogue box (see Figure 1) and then point to the cell address for the target cell. Since the total cost allocated to activity centers must be equal to the total direct costs from all resource centers, one must also click the "value of" radio button (see Figure 1) in the Solver Parameters dialogue box and type in the value for the total direct costs from all resource centers. Identifying the changing cells is just as intuitive. One would select the *changing cells* field and then point to the cell addresses for the *changing cells* (see Figure 1). Up to 200 *changing cells* may be used, implying that Solver can model a

Figure 1
Solver Parameters Dialogue Box
Excerpt from an Excel Template with Parameters for the ABC, Inc. Cost Allocation Problem



cost allocation problem for an entity with up to 200 resource centers.

Constraints are identified by clicking on the "Add" button (see Figure 1) and pointing to the relevant constraints in the Add Constraint dialogue box, which appears after the Add button is clicked. The Add Constraint dialogue box, shown in Figure 1, contains a drop down list that includes several comparison operators. The equal to operator must be selected since both sides of the constraint (the redistributed resource center cost computed by reference to the *changing cells*, B17:B21 in Figure 1, and the redistributed resource center cost determined by Solver in *the changing cells*, B12:F12 in Figure 1) must be equal after the allocation is complete. A maximum of 100 constraints may be added. Because Excel allows the user to enter individual constraints as vectors, only one constraint is needed to solve the reciprocal cost allocation problem. For example, the constraint employed in Figure 1—the vector B17:B21 is equal to the vector B12:F12—is equivalent to the five individual constraints B17=B12, B18=C12, B19=D12, B20=E12, and B21=F12.

Finally, clicking the Solve button in the Solver Parameters dialogue box solves the problem. This brings up the Solver Results dialogue box, shown in Figure 1. This box shows whether Solver has found a solution. Most cost allocation problems should be solved with the basic target cell/changing cells/constraint model described in this paper. However, if the Solver does not find a solution, the user should click the Options button shown in Figure 1 and increase the amount of time and the number of iterations that Solver uses to find a solution. None of the other options that appear in the Options dialogue box need to be changed.

The ABC, Inc. Solution

A complete model for ABC, Inc.'s cost allocation problem is shown in Table 2. All elements of the target cell/changing cells/constraint model discussed in the preceding paragraphs are pieced together and displayed. Costs allocated to activity centers are determined by multiplying the allocation proportions (a_{ij}) from service centers i to activity centers j by the redistributed costs for resource center i (x_i). For example, costs from Service Center 1 (see Table 2) is redistributed to Activity Center A (cell G17) by multiplying the redistributed costs from Service Center 1 (cell B17) times the proportion of service from Service Center 1 consumed by Activity Center A (cell G7)—i.e., Cell G17 = B17*G7. The solution is shown in Table 3. The total resource center costs allocated to Activity Centers A, B, and C are $21,753, $14,788, and $13,459, respectively. This solution is consistent with solutions from Williams and Griffin (1964) and Livingstone (1968) from which ABC, Inc.'s cost allocation problem is adapted.

Conclusion

This paper makes the case that electronic spreadsheet optimizers may be used as a tool in solving complex cost allocation problems that involve reciprocal relationships among several resource centers. Although the example used in the paper contains only five resource centers and three activity centers, it is possible to allocate costs from up to 200 resource centers by using an electronic spreadsheet optimizer such as Excel's Solver or Quattro Pro's Optimizer. Only the number of rows available in an electronic worksheet limits the number of activity centers that may be included in a cost allocation problem solved with either of these models. In theory, inserting additional worksheets into the template may also extend this limit.

Many cost and management accounting textbooks emphasize the direct method and the step method of service department cost allocations because the more theoretically correct reciprocal method is considered too complex. Contemporary electronic spreadsheets have, however, made it easier to apply the reciprocal method of cost allocations. Although a number of authors

Table 2
Using Solver to Apply the Reciprocal Method
A Cost Allocation Model for ABC, Inc.

	A	B	C	D	E	F	G	H	I	J	K
1											
2	Direct Costs and Allocation Proportions										
3											
4		Resource Centers					Activity Centers				
5		1	2	3	4	5	A	B	C	Total	
6	Direct Costs	8000	12000	6000	11000	13000					
7	Resource Center 1	0	0	0.1	0.05	0.1	0.25	0.25	0.25	=SUM(B7:I7)	
8	Resource Center 2	0	0	0.1	0	0.1	0.8	0	0	=SUM(B8:I8)	
9	Resource Center 3	0.05	0.1	0	0.1	0.05	0.2	0.3	0.2	=SUM(B9:I9)	
10	Resource Center 4	0.1	0.05	0.05	0	0	0	0.4	0.4	=SUM(B10:I10)	
11	Resource Center 5	0.2	0.2	0.2	0.2	0	0.1	0.05	0.05	=SUM(B11:I11)	
12	Redistributed Costs (Changing Cells)	13657.4658728727	17503.59448717	13290.6368392	16368.0645531	16780.63787					
13											
14	Costs Allocated from Resource Centers to A										
15							Activity Centers				
16		Redistributed Costs (Calculated)					A	B	C	Total	
17	Resource Center 1	=+B6+B7*B12+B8*C12+B9*D12+B10*E12+B11*F12					=$B17*G7	=$B17*H7	=$B17*I7	=SUM(G17:I17)	
18	Resource Center 2	=C6+C7*B12+C8*C12+C9*D12+C10*E12+C11*F12					=$B18*G8	=$B18*H8	=$B18*I8	=SUM(G18:I18)	
19	Resource Center 3	=D6+D7*B12+D8*C12+D9*D12+D10*E12+D11*F12					=$B19*G9	=$B19*H9	=$B19*I9	=SUM(G19:I19)	
20	Resource Center 4	=E6+E7*B12+E8*C12+E9*D12+E10*E12+E11*F12					=$B20*G10	=$B20*H10	=$B20*I10	=SUM(G20:I20)	
21	Resource Center 5	=+F6+F7*B12+F8*C12+F9*D12+F10*E12+F11*F12					=$B21*G11	=$B21*H11	=$B21*I11	=SUM(G21:I21)	
22	Total	=SUM(B17:B21)					=SUM(G17:G21)	=SUM(H17:H21)	=SUM(I17:I21)	=SUM(J17:J21)	
23											
24											
25											
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42											

These cells are computed by Solver by automatically changing their values until the constraints are satisfied.

This cell must total $50,000, which is the total direct costs incurred by all resource centers.

These cells should exactly match the "changing cells" when the solution is complete.

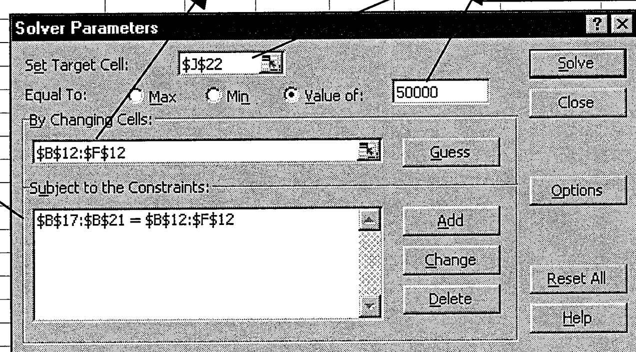

Table 3
Using Solver to Apply the Reciprocal Method Solution to ABC, Inc.'s Cost Allocation Problem

Direct Costs and Allocation Proportions

	Resource Centers					Activity Centers			
	1	2	3	4	5	A	B	C	Total
Direct Costs	$ 8,000	$ 12,000	$ 6,000	$11,000	$ 13,000				
Resource Center 1	0%	0%	10%	5%	10%	25%	25%	25%	100%
Resource Center 2	0%	0%	10%	0%	10%	80%	0%	0%	100%
Resource Center 3	5%	10%	0%	10%	5%	20%	30%	20%	100%
Resource Center 4	10%	5%	5%	0%	0%	0%	40%	40%	100%
Resource Center 5	20%	20%	20%	20%	0%	10%	5%	5%	100%
Redistributed Costs (Changing Cells)	$ 13,657	$ 17,504	$ 13,291	$16,368	$ 16,781				

Allocations from Resource Centers to Activity Centers

	Redistributed Costs (Calculated)	Costs Allocated to Activity Centers			
		A	B	C	Total
Resource Center 1	$ 13,657	$ 3,414	$ 3,414	$ 3,414	$ 10,243
Resource Center 2	17,504	14,003	-	-	14,003
Resource Center 3	13,291	2,658	3,987	2,658	9,303
Resource Center 4	16,368	-	6,547	6,547	13,094
Resource Center 5	16,781	1,678	839	839	3,356
Total*	$ 77,600	$ 21,753	$ 14,788	$13,459	$ 50,000

*footing errors are due to rounding.

method of cost allocations. Although a number of authors have written about the use of electronic spreadsheets for cost allocations (e.g., Brown and Killough, 1988; Pirrong and Bain, 1989; Burch, 1994; Jennings and Day, 1997; Savage and Wilburn, 1997), several problems restrict the applicability of their techniques and procedures. These authors employed matrix operations (Brown and Killough, 1988; Jennings and Day, 1997), used procedures that resulted in circular errors (Burch, 1994; Savage and Wilburn, 1997), or proposed cumbersome and unwieldy techniques that require repetitive copying, pasting, and recalculating (Pirrong and Bain, 1989). As illustrated in this paper, use of electronic spreadsheet optimizers avoids all of these problems. Although it is necessary to understand the logical relationships that exist between resource centers, knowledge of matrix algebra is not a prerequisite for using spreadsheet optimizers. Similarly, no circular errors are encountered, and there is no repetitive copying, pasting, and recalculating when a spreadsheet optimizer is used to apply the reciprocal method.

After identifying the direct costs incurred in each resource center and the relevant allocation proportions, applying an electronic spreadsheet optimizer requires the following five intuitive steps:

1. identify the area of the spreadsheet that will be used by the optimizer for the changing cells;
2. model the computed redistributed costs from each service center;
3. model the costs allocated from resource centers to activity centers by multiplying the computed redistributed costs from each service department by the appropriate allocation proportions;
4. model the row and column totals for the costs allocated to activity centers; and
5. use optimizer's target cell/changing cell/constraints model to solve the problem.

Judged in terms of the number of steps involved to build the model and the ease of applying those steps, the target cell/changing cells/constraints model applied using a spreadsheet optimizer makes the reciprocal method almost as easy as the direct method and somewhat easier than the step method of service cost allocation. Apart from a fundamental knowledge of spreadsheet optimizers as presented in this paper, students and practitioners who are currently able to use electronic spreadsheets to apply the direct method or the step method do not need any incremental knowledge of Excel or Quattro Pro to apply an optimizer's target cell/changing cells/constraints model. 🕮

Endnotes

1. Some simple applications may be modeled and solved with only two parameters—a target cell and changing cells.
2. Resource center and service department will be used interchangeably throughout the remainder of the paper. Activity center and production center will also be used interchangeably.

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