Maile-Ann Company:
A Matrix Approach To Reciprocated
Support Department Cost Allocations

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ABSTRACT

The reciprocal method for allocating support department costs has been shown to be better than the direct and step-down methods. In addition, a matrix approach for the reciprocal method has been presented often in academic journals. Yet, the instructional use of spreadsheet matrix functions for reciprocal cost allocations has been limited as many authors continue to present two-department simultaneous equations solved by algebraic substitutions. The Maile-Ann Company presents an intuitive matrix approach to allocating reciprocated costs of many support departments. The case converts commonly used algebraic expressions of support department reciprocated costs into an equivalent matrix relationship. Spreadsheet matrix functions compute each support department's reciprocated costs and allocate them to user departments.

Keywords: support department cost allocation, reciprocal method, matrix algebra

INTRODUCTION

$\mathcal{T}$he allocation of costs from support departments to operating departments is an important concept taught in most cost accounting courses (e.g., Hilton et al., 2003; Horngren et al., 2006). The overall objective of support department cost allocations to operating departments is to have more accurate product, service and customer costs (Horngren et al., 2006). Hence, support department cost allocations should reflect actual services provided to other support departments and operating departments.

In today's business organizations, there is an increase in the cost of support departments, an increase in the number of support departments, and an increase in the amount of services that they provide to other support departments. With a more complex business environment, the allocation of support department costs becomes more challenging. Textbook authors correctly identify the shortcomings of the direct and step-down methods, and recognize the reciprocal method as the most accurate support department cost allocation (Horngren et al., 2006).

Even though the reciprocal method is better suited to meet a changing business environment, accounting textbook authors have been hesitant to promote spreadsheet techniques in solving simultaneous equations for complex interrelationships of support departments within organizations. End-of-chapter problems for the direct and step-down methods often utilize arithmetic spreadsheet functions; however, matrix algebra spreadsheet techniques for solving reciprocal cost allocations are seldom presented even when they are readily available.

The next section is a brief overview of three common support department cost allocation methods and their related spreadsheet use. The concluding section presents the Maile-Ann Company case that utilizes matrix functions to easily represent and solve reciprocated costs of support departments.

COST ALLOCATION METHODS AND SPREADSHEET USE

Textbook authors (e.g., Hilton et al., 2003; Horngren et al., 2006) normally present three methods to allocate support department costs: direct, step-down, and reciprocal. The direct method is the simplest to use and, as

a result, the most widely used cost allocation procedure. It allocates support department costs only to operating departments and disregards the important and increasing services among support departments. A spreadsheet for the direct method would compute the percentages of use by operating departments, and then allocate the support department's cost based on the percentages. A spreadsheet is convenient in that it replaces a calculator, but there are limited learning benefits from using a spreadsheet.

The step-down method allows for partial recognition of support services provided to other support departments. Partial recognition occurs when a closed support department (i.e., a step-down) cannot receive allocations from remaining support departments. The partial recognition of support services and different sequences in closing support departments have been found to be disadvantages in using the step-down method (Horngren et al., 2006). A spreadsheet for the step-down method would calculate the percentages of use by remaining support departments and operating departments at each step, and then allocate the support department's cost based on the percentages. The use of a spreadsheet facilitates the many calculations of the step down method, but conceptually it is unlikely to increase the students' understanding of the allocation method.

The reciprocal method fully recognizes services among support departments. It explicitly includes them in defining a support department's reciprocated costs as its own cost plus any interdepartmental costs allocated to it from other support departments. The reciprocal method is a significant improvement over the direct and the step-down methods as it fully recognizes support services to all departments. This method requires that a set of independent linear equations be solved simultaneously, wherein there must be at least n variables for the n support departments. The simultaneous equations can be solved using algebraic techniques such that $n-1$ variables are methodically eliminated until a single variable is solved from one equation (e.g., Horngren et al., 2006). This can be a trying exercise for students and time consuming for instructors, especially if there are three or more support departments. This weakness in the mathematics skills of students probably coincides with textbooks presenting just two support departments, even though it is unrealistic in today's business environment.

Independent simultaneous equations can be solved very easily using matrix function found in spreadsheets. Furthermore, the matrix approach can capture complex relationships among many support departments and operating departments. The computed reciprocated costs of each support department can also be allocated to the other support and operating departments using a matrix function. The matrix approach facilitates the students' solving for reciprocated costs of support departments. While some students may not fully understand the matrix functions required to solve the set of linear equations, they will better understand the benefits of the reciprocal method and not be hindered with the mathematics. Students learn matrix functions that enhance their spreadsheet skills. The following Maile-Ann Company demonstrates the matrix approach for reciprocal cost allocations of support departments.

MAILE-ANN COMPANY

Overview

A manufacturer of electronic aircraft equipment, Maile-Ann Company incurs significant costs in support Departments A, B, C and D. Management has used the direct method to allocate support department costs to operating Departments X, Y and Z. However, with increased government contracts, management anticipates audits by government agencies and recognizes improvements to its cost accounting system are necessary to reflect more accurate product costs.

The CFO reviews the accounting literature and recognizes the reciprocal method for support department cost allocations as the best method to adopt. A review of cost accounting textbooks show how the reciprocated costs for two support departments should be calculated. However, the CFO is unable to solve a four support department reciprocated cost allocation using an algebraic approach. Furthermore, he knows that even more support departments will be needed as they expand into government work. He rereads the accounting textbook and determines that a spreadsheet matrix approach is available, although not demonstrated, for allocating support department costs using the reciprocal method. The CFO emails the cost accounting staff hoping to find this skill.

Jordan Kekoa is a recent addition to the cost accounting group and had been taught to apply the reciprocal method using a matrix approach. When Jordan responds to the CFO's email, he is immediately sent information and asked to present a spreadsheet matrix solution to the current cost allocations.

Data for Support Department Allocations

The costs for four support departments A, B, C, and D and three operating departments X, Y, and Z before any cost allocations are presented in Panel A of Table 1. In addition, the percent of support services provided by departments A, B, C and D to the other departments is displayed. For example, Department B provides 0.09 and 0.30 of its services to Departments A and X. Support services provided to its own department are not necessary as they are contained within the amount for reciprocated cost (Horngren et al, 2006).

The **-1.00** listed for support departments represents their **allocated** reciprocated services. Since the total of reciprocated services provided by a support department is equal to 1.00 and all of it will then be allocated to other user departments, the total for each support department is equal to 0.00.

Table 1: Reciprocated Cost Allocations

Panel A – Cost Data and Support Services Provided

	Dept A	Dept B	Dept C	Dept D	Dept X	Dept Y	Dept Z	Total
Department costs:	900,000	600,000	500,000	300,000	8,500,000	5,000,000	4,200,000	20,000,000
Support by:								
Dept A	**-1.00**	0.08	0.07	0.05	0.40	0.25	0.15	0.00
Dept B	0.09	**-1.00**	0.03	0.06	0.30	0.35	0.17	0.00
Dept C	0.05	0.06	**-1.00**	0.04	0.40	0.25	0.20	0.00
Dept D	0.03	0.07	0.04	**-1.00**	0.32	0.40	0.14	0.00

Panel B – Reciprocated Cost Allocations

	Dept A	Dept B	Dept C	Dept D	Dept X	Dept Y	Dept Z	Total
Department costs:	900,000	600,000	500,000	300,000	8,500,000	5,000,000	4,200,000	20,000,000
Allocations:								
Dept A	-1,010,300	80,824	70,721	50,515	404,120	252,575	151,545	0.00
Dept B	67,212	-746,799	22,404	44,808	224,040	261,380	126,955	0.00
Dept C	30,496	36,595	-609,914	24,397	243,965	152,478	121,983	0.00
Dept D	12,592	29,380	16,789	-419,720	134,310	167,888	58,761	0.00
Total	0.00	0.00	0.00	0.00	9,506,435	5,834,321	4,659,244	20,000,000

Algebraic Expressions for Reciprocated Costs

In the following algebraic expressions, A, B, C and D represent the reciprocated costs for corresponding departments. In Expression 1 for Department A, the reciprocated cost 1.00A is equal to its own cost of $900,000 and 0.09 of Department B's reciprocated cost, 0.05 of Department C and 0.03 of Department D. An equivalent algebraic expression for reciprocated costs can also be obtained from each column of a support department. In Expression 2 for Department A, the reciprocated cost has the equation: 900,000 -1.00A + 0.09B + 0.05C + 0.03D = 0. Similarly, the last four equations for Departments A, B, C and D represent the set of independent linear equations necessary to simultaneously solve for reciprocated costs of each department.

Department A:
        Expression 1 $+1.00A = 900,000 + 0.09B + 0.05C + 0.03D$
    or   Expression 2 $900,000 - 1.00A + 0.09B + 0.05C + 0.03D = 0$

Department A: +1.00A – 0.09B – 0.05C – 0.03D = 900,000
Department B: –0.08A + 1.00B – 0.06C – 0.07D = 600,000
Department C: –0.07A – 0.03B + 1.00C – 0.04D = 500,000
Department D: –0.05A – 0.06B – 0.04C + 1.00D = 300,000

Matrix Relationship and Reciprocated Cost Solution

The above set of simultaneous linear equations for Departments A, B, C and D is conveniently formatted for conversion to a matrix format. The following matrix relationship **S x X = K** is equivalent to the set of four simultaneous equations. The **S** matrix (4x4) represents reciprocated services among support departments. The **X** matrix (4x1) represents the support departments' unknown reciprocated costs noted as variables A, B, C, and D. The **K** matrix (4x1) represents the constants given as the individual cost of each department before any allocations. Each value within a matrix can be identified by a notation specifying the matrix and its location by row and column. For example, $(s_{2,3})$ is equal to -0.06 as it is found in the **S** matrix at row 2 and column 3. An example of an array of numbers is noted as $(s_{1,1}:s_{4,4})$, which is equivalent to the **S** matrix.

		S		x	X	=	K
+1.00	–0.09	–0.05	–0.03		A		900,000
–0.08	+1.00	–0.06	–0.07	x	B	=	600,000
–0.07	–0.03	+1.00	–0.04		C		500,000
–0.05	–0.06	–0.04	+1.00		D		300,000

The reciprocated cost solution for each department is computed mathematically by multiplying both sides of the matrix equation with the **inverse of S or S^{-1}**.

$$S \times X = K$$
$$S^{-1} \times S \times X = S^{-1} \times K$$
$$X = S^{-1} \times K$$

The following EXCEL formula multiplies **S^{-1}** with the **K** matrix to solve for **X**, which is a matrix for reciprocated costs of each department. After selecting a range (4x1) for the solutions to be displayed, enter the formula and press **Ctrl + Shift + Enter** keys together. The solution matrix for the reciprocated costs for departments A, B, C and D is shown below.

EXCEL formula: =mmult(minverse(S),K) or =mmult(minverse($s_{1,1}:s_{4,4}$),$k_{1,1}:k_{4,1}$)

	A =	*1,010,300*
Solution	*B =*	*746,799*
	C =	*609,914*
	D =	*419,720*

Reciprocated Cost Allocations

The allocation of reciprocated costs for each support department to all other departments is performed by multiplying two matrices. The **R x P = A** matrix multiplication is shown below, where the **R** matrix (4x4) of reciprocated costs for each department is multiplied by the **P** matrix (4x7) which is the table of services provided by support departments found in Panel A. The EXCEL formula for the matrix multiplication is also shown. In Panel B of Table 1, the resultant **A** matrix (4x7) is the allocation of reciprocated costs of support departments to all other departments. The cost allocation is complete as Departments A, B, C and D have zero balances and the total costs of all departments remain the same at $20,000,000.

R				**x**	**P**							**= A**
1,010,300	0.00	0.00	0.00		-1.00	0.08	0.07	0.05	0.40	0.25	0.15	
0.00	746,799	0.00	0.00	x	0.09	-1.00	0.03	0.06	0.30	0.35	0.17	= A
0.00	0.00	609,914	0.00		0.05	0.06	-1.00	0.04	0.40	0.25	0.20	
0.00	0.00	0.00	419,720		0.03	0.07	0.04	-1.00	0.32	0.40	0.14	

EXCEL formula: =mmult(R,P) or =mmult(($r_{1,1}$:$r_{4,4}$),($p_{1,1}$:$p_{4,7}$))

CONCLUSION

The Maile-Ann Company case demonstrates the ease in using spreadsheet matrix functions to solve reciprocal cost allocations of support departments. This intuitive spreadsheet matrix approach for the preferred reciprocal cost allocation method can be easily adapted for more service and operating departments. This is another spreadsheet skill that accounting students should acquire in preparing for a more complex cost accounting environment given today's business organizations.

AUTHOR INFORMATION

Dennis F. Togo is professor of accounting at the University of New Mexico. He holds bachelor degrees in mathematics and accounting, and a master of accountancy from Brigham Young University. His doctorate is from Arizona State University. Dennis teaches cost accounting and accounting information systems. His research interests are in accounting education related to the use of computers to improve instruction and learning.

REFERENCES

1.   Hilton, Ronald W., Michael W. Maher and Frank H. Selto, *Cost Management: Strategies for Business Decisions,* McGraw-Hill/Irwin, New York, 2003.
2.   Horngren, Charles T., George Foster and Srikant M. Datar, *Cost Accounting: A Managerial Emphasis*, Prentice-Hall, Upper Saddle River, New Jersey, 2006.

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