

Activity Based Costing With Reciprocal Dollar Value Allocation

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Abstract

The general model of Activity Based Costing (ABC) allocates indirect costs to products using a two-stage procedure which first assigns overhead costs to homogeneous cost pools and then assigns those costs directly to products based on the products' use of activities. This procedure does not consider cross-servicing between service departments or activity centers, but rather uses the "direct method" of cost allocation. This paper presents Activity Based Costing with Reciprocal Dollar Value Allocation (ABC-RDVA) as one approach to using ABC in an environment where production service departments experience a substantial level of cross-servicing, and use of the "direct method" would distort product costs.

Introduction

Activity Based Costing (ABC) has a history of many successes (Mecimore and Bell, 1995; and Turney, 1991). However, the general model of ABC, using the plant-wide approach to assigning indirect costs to products (Cooper, 1990), has limitations and it can cause product costing distortions in companies that have significant amounts of cross-servicing between production service departments. The use of plant-wide overhead application rates in ABC (Keys and Lefevre, 1995) effectively results in using the "direct method" of overhead cost allocation (Atkinson et al., 1995, pp. 291). For over a quarter century accountants have known that the direct method of overhead cost allocation is simple and inexpensive, but that it should not be used if there is a significant amount of cross-servicing between the production service departments because it can cause

product cost distortions (Dopuch and Birnberg, 1969, pp. 286). Limiting ABC to effectively using the direct method, by using plant-wide application rates which ignore cross-servicing, forces companies with significant levels of cross-servicing to either forego the benefits of ABC or knowingly create product cost distortion by ignoring the effects of production service department cross-servicing. This article presents an analysis that demonstrates a situation in which traditional ABC allocations would cause substantial product cost distortion due to significant cross-servicing between the production service departments. It then presents Activity Based Costing with Reciprocal Dollar Value Allocation (ABC-RDVA) as one solution to dealing with this situation without losing the many benefits of ABC.

Illustration Overview

The analysis that follows is based on a

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fairly simple example. However, Activity Based Costing with Reciprocal Dollar Value Allocation (ABC-RDVA) is equally suitable in very complex circumstances. The company data used in this illustration has two production service departments and four products. Each of the two production service departments has two homogeneous cost pools (each, by definition, is driven by a single cost driver activity). Service Department One's cost pools are identified as "Activity A" and "Activity B," Service Department Two's cost pools are identified as "Activity C" and "Activity D," and the four products are identified as products "One," "Two," "Three," and "Four."

Cost and Activity Data

A summary of the company's cost and activity data is shown in Table 1. The first two lines of the example company's Activity and Cost Summary show summary information from the two production service departments. The top line is the number of units of the respective activities that each service department performed for its "customers," (the four products and the other production service department) during that period. The second line shows the direct cost incurred in performing those activities.

Activity consumption is accumulated for the four products and for the production service departments. The company records the number of the units of Activities A and B consumed by Service Department Two and the four products. They also record the number of the units of Activities C and D consumed by Service Department One and the four products. These data are shown in Table 1. The company could also accumulate activity consumption data at the "cost pool" level and perform the ABC-RDVA cost allocations using four cost pools rather than two service departments.

Table 1
Activity and Cost Summary

	Service Department One		Service Department Two		Products			
	Activity A	Activity B	Activity C	Activity D	One	Two	Three	Four
Activity Measures (in units)	10,000	50,000	100,000	200,000				
Total Cost Incurred	\$70,000	\$120,000	\$800,000	\$600,000				
Consumption of Activity A by Products & Dept Two			3,000		600	1,200	1,900	3,300
Consumption of Activity B by Products & Dept Two			20,000		3,000	5,000	7,000	15,000
Consumption of Activity C by Products & Dept One					15,000	12,000	8,000	5,000
Consumption of Activity D by Products & Dept One					40,000	30,000	20,000	10,000

Cross-Service between Production Service Departments

The focus of this article is the activities that the two production service departments provide for each other; the "cross-servicing." The 3,000 units of activity "A" and the 20,000 units of activity "B" consumed by Service Department Two are a legitimate cost of operating Service Department Two. The 60,000 units of activity "C" and the 100,000 units of activity "D" consumed by Service Department One are a legitimate cost of operating Service Department One. The general model of ABC, using plant-wide allocation rates, and the traditional "Direct Method" of allocating overhead costs both ignore this cross-servicing between the production service departments, and base their activity unit cost on the cost incurred by the production service department "activity cost pool" divided by the activities provided to the four products.

Traditional Activity Based Costing Allocations using the Direct Method

The overhead cost allocations the company would make using traditional Activity Based Costing are shown in Table 2. The activity cost per unit is developed by dividing the cost incurred in the activity cost pool by the activity volume provided to the four products (ignoring the activities performed for the other production service department). For Activity "A" the total cost of \$70,000 is spread over the 7,000 units of Activity "A" provided to the four products (see Table 2, Activity A Consumption). The resulting application rate for Activity "A" is \$10.00 per unit. This allocation procedure ignores the 3,000 units of Activity "A" consumed by Production Service Department Two and spreads the cost of producing those 3,000 units of Activity "A" over the 7,000 remaining units consumed by the

Table 2
Activity Based Costing Allocations

	Service Department One				Service Department Two				Products			
	Activity A	Activity B	Activity C	Activity D	Activity A	Activity B	Activity C	Activity D	One	Two	Three	Four
Activity Measures (in units)	7,000	30,000		40,000					100,000			
Total Cost Incurred	\$70,000	\$120,000	\$800,000	\$600,000								
Activity Cost Per Unit	\$10	\$4	\$20	\$6								
Activity A Consumption					600	1,200	1,900	3,300				
Cost allocation @ 10.00					\$6,000	\$12,000	\$19,000	\$33,000				
Activity B Consumption					3,000	5,000	7,000	15,000				
Cost allocation @ \$4.00					\$12,000	\$20,000	\$28,000	\$60,000				
Activity C Consumption					15,000	12,000	8,000	5,000				
Cost allocation @\$20.00					\$300,000	\$240,000	\$160,000	\$100,000				
Activity D Consumption					40,000	30,000	20,000	10,000				
Cost allocation @ \$6.00					\$240,000	\$180,000	\$120,000	\$60,000				
Total Service Cost Allocations To Products					\$558,000	\$452,000	\$327,000	\$253,000				

four products. Therefore, the products are charged \$10.00 per unit of Activity "A" rather than the \$7.00 actual cost (i.e. \$70,000 divided by 10,000) of producing each unit of Activity "A." As a consequence, each of the four products is over-charged more than 42 percent (\$10.00 versus \$7.00) for each unit of Activity "A" consumed. A more complicated difficulty caused by this omission is the understatement of the cost attributed to the activities (C and D) produced by Production Service Department Two. The effect of this lack of reciprocity in cost allocation is determined by the extent of the cross-servicing between the production service departments and the pattern of how the products consume the activities provided by the production service departments. The activity cost for Activities "B," "C," and "D" is allocated to the four products using the same procedure. The last line on Table 2 shows the "Total Service Cost Allocations To Products" using the traditional approach to Activity Based Costing.

Table 3
Reciprocal Dollar Value Allocation

	Service Department 1		Service Department 2		Products			
	Activity A	Activity B	Activity C	Activity D	One	Two	Three	Four
Total Activities Performed	10,000	50,000	100,000	200,000				
Total Cost Incurred	\$70,000	\$120,000	\$800,000	\$600,000				
Cost Per Unit Performed	\$7.00	\$2.40	\$8.00	\$3.00				
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Activity A Service Performed for Other Departments and Products (Units)			3,000	600	1,200	1,900	3,300	
Cost @ \$7.00			\$21,000	\$4,200	\$8,400	\$13,300	\$23,100	
Activity B Service Performed for Other Departments and Products (Units)			20,000	3,000	5,000	7,000	15,000	
Cost @ \$2.40			\$48,000	\$7,200	\$12,000	\$16,800	\$36,000	
Sub Total Service Department 1			\$69,000	\$11,400	\$20,400	\$30,100	\$59,100	
Percentage of Department 1's Cost			36.32%	6.00%	10.74%	15.84%	31.10%	
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Activity C Service Performed for Other Departments and Products (Units)				15,000	12,000	8,000	5,000	
Cost @ \$8.00				\$120,000	\$96,000	\$64,000	\$40,000	
Activity D Service Performed for Other Departments and Products (Units)				40,000	30,000	20,000	10,000	
Cost @ \$3.00				\$120,000	\$90,000	\$60,000	\$30,000	
Sub Total Service Department 2				\$240,000	\$186,000	\$124,000	\$70,000	
Percentage of Department 2's Cost				17.14%	13.29%	8.86%	5.00%	

Overview of Activity Based Costing with Reciprocal Dollar Value Allocation

If the company were to use the Reciprocal Dollar Value Allocation method in conjunction with ABC (ABC-RDVA), they would begin by including the activities consumed by the production service departments in their allocation process. Table 3 shows the ABC-RDVA computations for the unit cost of activities. The original activity measures for activities A, B, C and D (service calls, labor hours, production set-ups, machine hours, etc.) cannot be aggregated into a single production service department output measure. What the ABC-RDVA method does is determine the cost of those activities, aggregate the cost, and identify that cost as the "dollar value" of output. This cost is then a valid single measure of the output of each production service department and it can be the basis for traditional reciprocal allocation.

Activity Based Costing with Reciprocal Dollar Value Allocation - Activity Costs

In the first section of Table 3, the cost per activity unit is calculated by dividing the direct cost of producing the activities by the total activity volume (the volume provided to the four products plus that provided to the other production service department) shown on line one, Table 1. Section two, Table 3, shows the ABC-RDVA analysis of Service Department One's activities and direct cost. This analysis is in two steps. First, the activity cost for both of Service Department One's activities (A and B) is allocated to Service Department Two and the four products. This is simply a process of multiplying the volume of activities consumed by these customers times the activity unit cost. Service Department Two consumed a total of 3,000 units of Activity "A" (see Section 2, Table 3), Activity "A's" application rate is \$7.00 per unit (see Section 1, Table 3), so the cost allocated to Service Department Two for its use of Activity "A" is \$21,000. Activity "A" cost is allocated to the four products using the same \$7.00 per unit application rate. Activity "B"

cost is allocated using the same procedure.

The Dollar Value of Activities Consumed as a Single Measure of Activity Consumption

The second step in the allocation of Service Department One's cost is to determine the total "Dollar Value" of the services performed for Service Department Two and the four products. The Reciprocal Dollar Value Allocation method uses this "dollar value" of services performed as the single common measure of support provided by the production service departments to their customers. Once this is determined the company can proceed with a "traditional reciprocal allocation" solution that charges both of the production service departments for the activities provided to them by the other production service department.

For Service Department One, the total dollar value of the allocations are: \$69,000 (36.32%) to Service Department Two; \$11,400 (6.00%) to Product One; \$20,400 (10.74%) to Product Two; \$30,100 (15.84%) to Product Three; and \$59,100 (31.10%) to Product Four. The allocation of Service Department Two's costs, in section three of Table 3, follows the same procedure. Service Department Two's total dollar value allocations are \$780,000

**Table 4
Reciprocal Dollar Value Allocation**

$$\begin{aligned}
 S_1 &= \$70,000 + \$120,000 + 55.71\%S_2 \\
 S_2 &= \$800,000 + \$600,000 + 36.32\%S_1 \\
 \hline
 S_1 &= \$190,000 + .5571(\$1,400,000 + .3632S_1) \\
 S_1 &= \$190,000 + \$779,940 + .20233872S_1 \\
 S_1 &= \$969,940 + .20233872S_1 \\
 .79766128S_1 &= \$969,940 \\
 S_1 &= \$1,215,979.80 \\
 \hline
 S_2 &= \$1,400,000 + .3632(\$190,000 + .5571S_2) \\
 S_2 &= \$1,400,000 + \$69,008 + .20233872S_2 \\
 S_2 &= \$1,469,008 + .20233872S_2 \\
 .79766128S_2 &= \$1,469,008 \\
 S_2 &= \$1,841,643.86
 \end{aligned}$$

(55.71%) to Service Department One; \$240,000 (17.14%) to Product One; \$186,000 (13.29%) to Product Two; \$124,000 (8.86%) to Product Three; and \$70,000 (5.00%) to Product Four.

Using the Dollar Value Measures in a Traditional Reciprocal Allocation

The first step in carrying out the reciprocal allocation process is the calculation of the values of S_1 and S_2 . These amounts represent the “complete reciprocated cost” of production service departments one and two, and will be the basis for the simultaneous allocations of production service department cost to the other service department and the four products shown in Table 5. It is important to understand that the two percentages used in the definitions of S_1 and S_2 are proportions of one service department’s output that were provided to the other service department; as calculated in Table 3. The calculation of S_1 and S_2 is shown in Table 4. In the first section, the basic equations for S_1 and S_2 are defined. S_1 is the “complete reciprocated cost” of operating Production Service Department One. It includes the direct cost incurred to perform activities A and B (see Table 1) plus 55.71 percent of S_2 , the “complete reciprocated cost” of Production Service Department Two (section 3, Table 3). S_2 is defined as the direct cost incurred for activities C and D (see Table 1) plus 36.32 percent of S_1 , the “complete reciprocated cost” of Production Service Department One (see Section 2, Table 3).

The simultaneous solutions of equations S_1 and S_2 are shown in Table 4. The solutions show that the “complete reciprocated cost” of Production Service Department One is \$1,215,979.80 and the “complete reciprocated cost” of Production Service Department Two is \$1,841,643.86.

The allocation of production service department cost using Activity Based Costing with Reciprocal Dollar Value Allocation is shown in Table 5. The top line, “Service Dept. Cost,” is the direct cost incurred by the service departments (see Table 1). On line two, column one, the \$1,215,979.80 is the “complete reciprocated cost” of Service Department One (S_1) that is being allocated to Service Department Two and the four products. Service Department Two used 36.32 percent of Service Department One’s output (see Section 2, Table 3), so it is charged \$441,643.86 (36.32 percent of Service Department One’s “complete reciprocated cost”). The calculations of all of the cost allocations in Table 5 are shown in referenced endnotes. The total cost allocated to the four products using ABC-RDVA is shown on the last line of Table 5.

	Service Department 1	Service Department 2	Product 1	Product 2	Product 3	Product 4
Service Dept Cost	\$190,000.00	\$1,400,000.00				
Allocation of Service Dept 1's Cost	(\$1,215,979.80)	\$441,643.86 ¹	\$72,958.79 ²	\$130,596.23 ³	\$192,611.20 ⁴	\$378,169.72 ⁵
Allocation of Service Dept 2's Cost	\$1,025,979.80 ⁶	(\$1,841,643.86)	\$315,657.76 ⁷	\$244,754.47 ⁸	\$163,169.64 ⁹	\$92,082.19 ¹⁰
Totals	-0-	-0-	\$388,616.55	\$375,350.70	\$355,780.84	\$470,251.91

Table 6
Overhead Cost Allocation Comparison
Activity Based Costing Allocations Compared to Reciprocal Dollar Value Allocations

	Overhead Cost Allocated to Products			
	One	Two	Three	Four
Activity Based Costing Allocations	\$558,000.00	\$452,000.00	\$327,000.00	\$253,000.00
Reciprocal Dollar Value Allocations	388,616.55	375,350.70	355,780.84	470,251.91
Over or (Under) Costing of Products				
Using Plant-Wide ABC Allocations	\$169,383.45	\$76,649.30	(\$28,780.84)	(\$217,251.91)
Percentage Error in ABC Allocation	+ 44%	+ 20%	- 8%	- 46%

Comparing Product Costs Based on Traditional ABC with those Based on ABC-RDVA

A comparison of the total cost allocated to each of the products, using ABC with traditional plant-wide activity application rates (see Table 2) with the cost allocated using Activity Based Costing with Reciprocal Dollar Value Allocations (see Table 5), is shown in Table 6. The differences are dramatic and are caused by the cross-servicing between the two production service departments. In companies where cross-servicing between production service departments is insignificant, these differences will be insignificant. In companies where the cross-servicing is substantial, as in this example, these differences will be dramatic. Where there are significant differences, the question is which set of cost allocations is "correct" and which is "incorrect." Horngren, Foster, and Datar state (1994, pp. 515):

The reciprocal method, while theoretically the most defensible, is not widely used. The advantage of the direct and step-down methods is that they are relatively simple to compute and understand. However, with the ready availability of computer software to solve systems of simultaneous equations, the extra costs of using the reciprocal method will, in most cases, be minimal. The more likely roadblocks to the reciprocal method being widely adopted are (1) many managers find it difficult to understand, and (2) the numbers obtained by using the reciprocal method

differ little, in some cases, from those obtained by using the direct or step-down method."

Barfield, Raiborn and Dalton (1991, pp. 110) conclude that "While the algebraic (or reciprocal) method is the most complex of all of the allocation techniques, it is also theoretically the most correct and, if relationships are properly formulated, will provide the best allocations"

The issue of which approach is correct and which is incorrect appears to be fairly clear. The reciprocal allocation method appears to be the best approach. The direct method, used by traditional ABC, is less costly to use and easier for managers and accountants to understand. If the results of the two methods are not materially different, then use of the direct method is justified. In an environment where significant cross-servicing exists, the materiality of the differences cannot be determined unless the cost allocations are calculated using both methods.

Conclusion

The traditional approach to Activity Based Costing uses plant-wide application rates for charging the users of activities for the benefits received. These plant-wide application rates are developed based only on the activities consumed by "products." They are therefore based on the direct method of allocation and, consequently, ignore cross-servicing between produc-

tion service departments. The degree of error the direct method causes in product costing is based on the degree of cross-servicing and the pattern of activities consumed by the products. Where cross-servicing exists, the existence of error in ABC cost allocations is unquestionable. The amount of error is the issue. The improved method recommended here, Activity Based Costing with Reciprocal Dollar Value Allocations (ABC-RDVA), appears to be the best method of cost allocation when cross-servicing exists. In addition to improved product costing accuracy ABC-RDVA also retains a departmental orientation for the collection, analysis and allocation of indirect costs from production service departments. The question is whether the benefits achieved with ABC-RDVA are worth the additional cost of using it.


The great strength of ABC is the identification of activity costs and the refinement of cost allocation by using multiple cost drivers to allocate the cost of a single production service department. Its great weakness, thus far, may have been its inability to use multiple activities to simultaneously allocate cost in a cross-servicing environment and its consequent reliance on the direct method for allocating activity costs. ABC-RDVA retains ABC's great strength and eliminates what may be one of its weaknesses. The result should be improved product cost information for managers and more accurate activity costs for activity management. The use of ABC-RDVA should involve only a minimal cost because the entire process can be performed quickly and inexpensively with existing spreadsheet technology.

In an environment in which production service departments engage in significant levels of cross-servicing, ABC-RDVA provides improved product cost information for managers without a noticeable increase in cost. It should therefore be considered a value-added process.

Implications for Future Research

Two primary issues deserve attention. First, existing applications of ABC that have sig-

nificant levels of cross-servicing may be appropriate for ABC-RDVA. The difference in product cost may be significant. Second, companies with significant levels of cross-servicing that have not implemented ABC may now find it more acceptable to try.

Activity Based Costing with Reciprocal Dollar Value Allocation allows a refinement of ABC in those situations where significant cross-servicing exists between the production service departments. An important research question is whether ABC-RDVA can pass the cost-benefit test. 

Endnotes

1. Service Department Two's 36.32% consumption of Service Department One's output cost times \$1,215,979.80 equals \$441,643.86.
2. Product One's 6% consumption of Service Department One's output cost times \$1,215,979.80 equals \$72,958.79.
3. Product Two's 10.74% consumption of Service Department One's output cost times \$1,215,979.80 equals \$130,596.23.
4. Product Three's 15.84% consumption of Service Department One's output cost times \$1,215,979.80 equals \$192,611.20.
5. Product Four's 31.10% consumption of Service Department One's output cost times \$1,215,979.80 equals \$378,169.72.
6. Service Department One's 55.71% consumption of Service Department Two's output cost times \$1,841,643.86 equals \$1,025,979.80.
7. Product One's 17.14% consumption of Service Department Two's output cost times \$1,841,643.86 equals \$315,657.76.
8. Product Two's 13.29% consumption of Service Department Two's output cost times \$1,841,643.86 equals \$244,754.47.
9. Product Three's 8.86% consumption of Service Department Two's output cost times \$1,841,643.86 equals \$163,169.64.
10. Product Four's 5% consumption of Service Department Two's output cost times \$1,841,643.86 equals \$92,082.19.

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