A Practical Application of Multiple Activity Based Costing

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Abstract

Professors Cooper and Kaplan (1988a and 1988b) recommend the allocation of overhead based on "activities" which cause the overhead cost; a process they have named "Activity Based Costing" (ABC). ABC has thus far been limited to the use of a single activity to allocate any cost pool. This paper argues that most cost pools have multiple cost drivers and should therefore be allocated using multiple activities and introduces the concept of Multiple Activity Based Costing.

Introduction

The most important issue facing most managerial accountants, as well as many managers, is accurately determining the cost of their company's products and services. Accurate product cost information is essential to establishing product prices, determining which products are most profitable and viable, deciding which products should be developed and which should be dropped, and to capital allocation decisions. Managers simply must have accurate product cost information if their companies hope to compete in today's international markets.

One of the major problems in modern product costing is the allocation of overhead costs. The inadequacies of product costing in many large manufacturing firms is frequently noted in the accounting literature and has been documented by the field studies of Professors Kaplan and Cooper [1988a and 1988b] of Harvard University. Most often these firms have used direct labor as the basis for allocating overhead costs to products. The problems and distortions caused by this practice were not cause for alarm when overhead was 15 percent of total product cost and direct labor was easily identified. However, with overhead approaching 50, 60 or even 70 percent of total product cost while direct labor becomes less identifiable, the distortion caused by using simple labor related bases for allocating overhead has a greater impact on the quality of decisions made by managers. Companies simply cannot effectively compete in domestic or international markets unless they have accurate information to facilitate informed strategic product decisions.

Professors Cooper and Kaplan advocate Activity Based Costing (ABC) as a more accurate approach to allocating common overhead costs to products. ABC divides common overhead costs into cost pools that have a single purpose and then allocates that cost to products based on activities which drive the costs in these cost pools. Thus far, advocates of ABC have limited the allocation process to a single activity for each cost pool. If a single activity is the only cost driver for a cost pool, then that single activity is a good choice to use as the basis for allocating that cost to products. But if it is clear that more than one activity causes the costs in a cost pool, then how should we decide which activity should be used to allocate the cost to the products? If the choice of activity for allocating the cost pool causes a significant difference in how products share the overhead cost, then using any single activity will distort product costs. The only accurate approach to product costing then is the use of multiple activity based costing (MABC).

The purpose of this paper is to convince you that most overhead cost pools are driven by multiple activities, and that these multiple activity overhead cost pools can be accurately allocated to products using readily available technology.

Multiple Activity Based Costing (MABC)

The logic of ABC is that activities cause cost, products cause activities, and that the cost should be allocated to the products based on the activities. ABC is a major step forward from allocating overhead costs based on direct labor, but single activity ABC is only an interim step. The logical extension of ABC is Multiple Activity Based Costing (MABC). The reasoning is simple and clear. If multiple activities drive the cost then multiple activities should be used to allocate that cost.

Consider the relationship between activities and overhead cost in a typical production environment. ABC recommends that cost pools be established at the level where they involve the fewest possible "activities" because the cost will be allocated based on only one activity. If you evaluate the types of cost incurred by a typical Inventory Management Function (IMF) in a production environment, you are unlikely to be able to identify any single "activity" that causes the cost. Processing requisitions requires time and therefore causes the company to incur labor cost. The physical size and weight of the materials issued will also influence operating costs; size may dictate storage space requirements and weight may dictate equipment needs for handling and delivery. The value or cost of the materials may influence insurance costs, storage security, accountability procedures, and interest costs on invested capital. It is normally not possible to separate these different functions so that each will be identified with a separate "activity". The person who processes the requisition may also physically move and deliver the material. The space for storage, processing and administration may all be common. One manager will be in charge of all three activities. Any attempt to determine the separate cost of each of these three activities will require the allocation of common costs, and therefore degenerate into another allocation process. The simple and most effective way to deal with the problem is to use Multiple Activity Based Costing (MABC). Consider the following illustration:

A plant produces three products, A, B and C. They have a central Inventory Management Facility (IMF) that provides all of the material support for the three products. The costs of the IMF and selected "activities" are listed in Table 1. Five periods are used for clarity and ease of illustration; monthly data for 12 months could be substituted.

TABLE 1

Period IMF Overhead Cost	Number of Requisitions Processed	Cost of Materials Issued	Pounds of Materials Issued
$205,000	2,200	$330,000	76,000
236,000	3,300	360,000	83,000
248,000	4,000	353,000	88,000
225,000	2,900	347,000	82,000
240,000	3,700	351,000	84,000
$1,154,000	16,100	$1,741,000	413,000

Each of the three products cause varying amounts of all three of the activities. Their respective activity levels are shown in Table 2. If a single activity is used to allocate the overhead cost, all three of the cost allocations shown in Table 3 are possible. Product A could be allocated from $176,034 to $623,730. Product B could be allocated from $331,419 to $698,547. Product C could be allocated from $198,851 to $580,584. The "cost" of each product varies dramatically based on which single activity is used to allocate the overhead cost. Consequently, the product cost is determined by the choice of activity base for allocation, and therefore becomes arbitrary. The use of Multiple Activity Based Costing appears to be the only viable approach.

TABLE 2

Product	Number of Requisitions Processed		Cost of Materials Issued		Pounds of Materials Issued	
A	19%	3,000	54%	941,000	15%	63,000
B	31%	5,000	29%	500,000	61%	250,000
C	50%	8,100	17%	300,000	24%	100,000
Total		16,100		$1,741,000		413,000

TABLE 3
Overhead Cost Allocated Using

Product	Number of Requisitions Processed	Cost of Materials Issued	Pounds of Materials Issued
A	$215,031	$623,730	$176,034
B	358,385	331,419	698,547
C	580,584	198,851	279,419
	$1,154,000	$1,154,000	$1,154,000

Multiple Regression/Correlation Analysis

Multiple Activity Based Costing (MABC) requires the use of Multiple Regression/Correlation Analysis (MRCA). MRCA is a sophisticated statistical technique that has been available for years, but only recently has become so readily available and so simple to use. Lotus 1-2-3 (version 2.0 and above) includes a simple-to-use multiple regression/correlation analysis (MRCA) procedure. This procedure is simple enough to learn in an hour or two. The result is that virtually every company currently has the technology needed to implement Multiple Activity Based Costing (MABC).

Multiple Activity Based Costing (MABC) should involve three steps. First, determining the relationships between suspected cost drivers (activities) and the cost you want to apply to the products. Second, estimating future costs based on these established relationships. Third, determining the appropriate future overhead application rate for each "activity" that is a significant cost driver. Simply stated, past relationships are used to estimate future overhead costs and determine application rates for future production.

To make the introduction of this material less complex and easier to understand, we will use an illustration that is based on five periods (normally months) and three products.

The "activities" are independent variables, and overhead cost is the dependent variable. In Lotus 1-2-3 independent variables are "X variables" and dependent variables are "Y variables". In our illustration, Number of Requisitions Processed, Cost of Materials Issued, and Pounds of Materials Issued are the "X (independent) variables" and period Inventory Management Facility (IMF) Overhead Cost is the "Y (dependent) variable". The results of the regression/correlation analysis are shown in Table 4. The regression output provides a "constant" (an estimate of the fixed cost), an "R squared" value (the proportion of variation in the overhead cost that our "activities" account for), and three "X Coefficients" (that are effectively the variable cost per unit of each of the three "activities"). For the moment, let us limit the discussion to these three output components.

TABLE 4

Lotus 1-2-3 (version 2.2)
Regression/Correlation Analysis Output

Period	Overhead Cost	Number of Requisitions	Direct Materials Cost	Pounds of Direct Materials
1	$205,000	2,200	$330,000	76,000
2	236,000	3,300	360,000	83,000
3	248,000	4,000	353,000	88,000
4	225,000	2,900	347,000	82,000
5	240,000	3,700	351,000	84,000

Regression Output

Constant	18,508.36		
Std Error of Y Est	99.53		
R Squared	0.99999		
No of Observations	5		
Degress of Freedom	1		
X Coefficients	15.5378	0.309958	0.657778
Std Error of Coef	0.2845	0.007428	0.047172

The "constant" is the estimated IMF total overhead cost when all three "activities" are at "zero"; simply the fixed overhead cost per period. The "R Squared" value is always between zero and one. It is the proportion of the variation in the total IMF Overhead Cost that is explained by the variation in the "activities". It tells us how good the regression coefficients (the constant plus the X coefficients) describe the movement in the overhead cost, given knowledge of the "activities". Our results show .99999 which is about as good as you can ever expect. More likely, you will get R Squared values considerably smaller, but .50 or above should be useable. The "X Coefficients" are effectively the variable cost per unit of "activity" for each of the three activities.

Under single activity ABC we need an estimate of the total overhead cost for the coming year and an estimate of the level of the single activity that we use to apply

TABLE 5

Estimates of Future Activity Levels

Period	Number of Requisitions Processed	Cost of Materials Issued	Pounds of Materials Issued
1	2,000	$290,000	80,000
2	2,500	325,000	75,000
3	3,000	320,000	84,000
4	3,200	360,000	89,000
5	2,800	310,000	78,000

overhead. Using MABC we use our estimates of next year's activities to estimate total overhead cost and apply overhead to the product.

Using normal production budgeting procedures, we estimate the quantities of products we will produce during each of five months. From those estimates, we estimate the level of each of our three activities for each of the five months. These estimates are included in Table 5. During the first month we would estimate our total overhead cost as $18,508.36 (the constant from Table 4) plus $31,075.60 (2,000 times 15.5378 the first X coefficient) plus $89,887.82 ($290,000 times 0.309958 the second X coefficient) plus $52,622.40 (80,000 times 0.65778 the third X coefficient) = $192,094.18. The remaining four monthly estimates are included in Table 6. We now have the estimated overhead cost per month and the estimated activity level for each of the three activities for each of the five months (Table 5 and 6).

The procedure thus far has been to use prior period actual costs to determine the cost behavior pattern of overhead costs and our estimates of fixed cost per period and the variable cost per unit of activity. We then developed estimates of future production and the three activities for a future five month period. Combining the cost estimates and the estimates of future activities, we developed estimates of overhead costs for each of the five future months (Table 6). We are now at the point where

TABLE 6

Estimated Future Overhead Cost

		Cost Estimate Based on			
Period	Total	Fixed Cost Per Period	Number of Requisitions Processed	Cost of Materials Issued	Pounds of Materials Issued
1	$192,094.18	$18,508.36	$31,075.60	$89,887.82	$52,622.40
2	207,422.71	18,508.36	38,844.50	100,736.35	49,333.50
3	219,561.84	18,508.36	46,613.40	99,186.56	55,253.52
4	238,356.62	18,508.36	49,720.96	111,584.88	58,542.42
5	209,408.02	18,508.36	43,505.84	96,086.98	51,306.84

we can develop our overhead application rates for the five future months.

Multiple Regression/Correlation Analysis (MRCA) is used to develop coefficients that are overhead application rates for each of the three activities. We use the MRCA procedure with the future activity estimates and the estimates of future overhead cost (Tables 5 and 6) to develop revised "X coefficients" that can be used as overhead application rates. The MRCA table using Lotus 1-2-3 will be similar to Table 7. Note that the constant is zero. This is achieved by selecting a zero constant option from the Lotus 1-2-3 procedure menu. It forces all of the overhead cost to be allocated through the activities by recomputing X coefficients that account for all overhead cost. Using these recomputed X coefficients to allocate overhead cost to products assures that all overhead will be assigned to a product. Had we used the original X coefficients to allocate overhead cost, the fixed cost would remain unallocated at the end of the five periods. Forcing the constant to zero, forces all of the overhead cost to be accounted for by the three activities and assures that all of the overhead cost will be allocated to products. Overhead application using the recomputed X coefficients includes both the variable and fixed components of overhead cost.

TABLE 7
Using Regression/Correlation Analysis
To Develop Overhead Application Rates

Period	Total Overhead Cost	Number of Requisitions Processed	Cost of Materials Issued	Pounds of Materials Issued
1	$192,094.18	2,000	$290,000	80,000
2	207,422.71	2,500	325,000	75,000
3	219,561.84	3,000	320,000	84,000
4	238,356.62	3,200	360,000	89,000
5	209,408.02	2,800	310,000	78,000

Regression Output:

Constant	0		
Std error of Y est	1396.61		
R Squared	0.99665548		
No. of Observations	5		
Degrees of Freedom	2		
X Coefficients	13.4202955	0.3472860	0.8080407
Std Error of Coeff	2.1971236	0.0403451	0.1341163

For the future five months, each product will be assigned overhead based on $13.42 per requisition, 34.73 percent of the cost of materials issued, and $0.81 per pound of materials issued.

More Sophisticated Applications

The above has been a basic introduction to Multiple Activity Based Costing (MABC). The use of Multiple Regression/Correlation Analysis (MRCA) is the basis for this new approach to product costing. MRCA is relatively simple to use in its basic form, but new users should also be aware of some additional concerns.

The illustration we used here was simple because it was intended to be easy to understand. Two additional aspects need to be considered. First, how valid or useable are the X coefficients? Second, how do you decide which activities are cost drivers? We will address each of these topics in appendices for those who are interested in learning more of the technical details. Appendix A addresses the usability of the X coefficients. Appendix B addresses the process of deciding which activities are cost drivers.

Summary and Conclusions

The move away from using direct labor as the basis for overhead application has been a major achievement. Activity Based Costing (ABC) has demonstrated that overhead costs can be more accurately allocated on a rational and logical basis, and that it is activities rather than direct labor that drive overhead costs. Multiple Activity Based Costing is the logical extension of ABC. It acknowledges that overhead cost pools are not normally driven by a single activity - organizational functions are multi-dimensional. It allows the consideration of all possible activities and selects those that have the most impact on overhead cost.

Adopters of MABC are encouraged to explore the basics of Multiple Regression/Correlation Analysis and to read through appendices A and B before attempting an application. Applications of this new technology are not difficult, but they do require time to develop and learn. An excellent reference for Multiple Regression/Correlation Analysis is Cohen and Cohen (1983). Lotus 1-2-3 provides easy access to the computational procedures and requires only a minimum of start-up time. ❧

✻✻✻ References ✻✻✻

1. Cohen, Jacob and Cohen, Patricia, *Applied Multiple Regression/Correlation Analysis for the Behavioral Sciences*, 2nd Ed., Lawrence Erlbaum Assoc, Hillsdale, New Jersey, 1983.
2. Cooper, Robin and Kaplan, Robert S., "How Cost Accounting Distorts Product Costs," *Management Accounting*, Vol LXIX, No. 10, pp. 20-27, 1988.
3. Cooper, Robin and Kaplan, Robert S., "Measure Costs Right: Make the Right Decisions," *Harvard Business Review*, Vol. 88, No. 5, pp. 96-103, 1988.

Appendix A

Determining If X Coefficients Are Usable

The following describes two ways to test to see if the X Coefficients are usable for cost estimating and overhead application.

The first test is the sign of the X Coefficient. If it is negative it is most likely unusable for our purposes. A negative coefficient indicates a negative cost or a revenue. This means that the more that activity is performed the lower the cost will be. This is possible, and a negative coefficient may be valid, but it is highly unlikely. More importantly, we are looking for cost drivers, not revenue drivers.

The second test is equally easy to apply, but perhaps more difficult to understand. The last line of the regression output from Lotus 1-2-3 shows the standard errors of the x coefficients. Dividing the X coefficients by their standard errors should produce a result greater than 2.0.

The X coefficients are the average amount of change in total overhead cost associated with a one unit change in the constant. So, the X coefficients are means of distributions, and their standard errors describe those distributions. The smaller the standard error (relative to the X coefficient) the closer each value in the distribution is to the mean, and the better the mean describes the entire population. The ratio of the X coefficient to its standard error is a "t value" that can be interpreted using a table of student t distributions. For most purposes a value of 2.0 or higher is desirable.

Appendix B

Identification of Cost Drivers

Cost driver identification is basically a cost behavior analysis. In any environment, it is probably useful to identify suspected cost drivers – those activities that would logically seem to cause cost to increase. Activity measures for each period (normally a month) need to be obtained. The total overhead cost for the same periods also needs to be determined. Generally, a twelve month period should be sufficient.

If eight or ten suspected cost drivers have been identified, you must determine which, if any, are valid cost drivers. The best way to start is to perform a regression analysis using all of the activities as independent variables. The purpose of this trial run is to see if all of the activities combined explain a sufficient amount of the variation in overhead cost behavior. This is done by evaluating the R Squared value in the regression output table. It should be at least .50 and preferably above .80. If the R Squared value is below .50. the activities you have selected are not your dominant cost drivers. Try some other activities. If the R Squared value is acceptable, then the question is which of the activities are the cost drivers.

Identifying the cost drivers is best achieved using a procedure called Step Wise Multiple Regression. It is a procedure which adds one activity at a time to the regression process, and it adds them in order of their explanatory power (by how much they increment the R Squared value).

The process begins by regressing each of the activities against total overhead cost and observing the R Squared value produced by each individual activity. The activity producing the highest R Squared value is selected as the first "included activity". The second step is to combine this first "included activity" with each of the remaining activities, and regress the pairs against total overhead cost. The pair which result in the highest R Squared value are selected as "included activities". The third step is to combine the two "included activities" with each of the remaining activities, and determine which three activities result in the highest R Squared value. Those three activities are then selected as "included activities". This process is repeated until the increment to the R Squared value is insignificant; normally about .01.

Once the cost drivers have been selected, they should be evaluated using the procedures in Appendix A.