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Full Length Research Paper

Comparison of methods for allocation of service departments' costs to operating departments: A Monte Carlo simulation

Suleyman Yukcu[1] and Hakan Ozkaya[2]*

[1]Dokuz Eylul University, Izmir, Turkey.

[2]Yasar University, Faculty of Economics and Administrative Sciences, Universite Cad., No: 35, 35500, Bornova, Izmir-Turkey.

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In this paper; the performance of widely used methods for allocation of multiple service departments costs to operating departments, namely direct method and two different applications of step-down method, were compared by using the criteria of deviation of their results from those of reciprocal method which is posited as the most accurate method for allocation. Moreover the conditions under which each method yielded the best results were presented. Our dataset included randomly obtained 10,000 observations with different percentages of service provided by service departments and different cost figures. Results indicated that the application of step-down method which considered percentage of service provided as the base for ranking service departments yielded least deviation from results of reciprocal method on average, and yielded the best results with highest probability and the worst results with the least probability, thus provided more accurate results than competing methods.

Key words: Cost allocation, service departments' costs, direct method, step-down method, reciprocal method.

INTRODUCTION

It is often stated by cost accounting doyennes that cost accounting can not produce precise cost figures but try to achieve the closest possible. The main reason for the statement is the fact that cost accounting practices need various allocation methods with various allocation bases to estimate cost figures. Thus allocation of costs is of at most important issue in cost accounting and has been always in the very center of debates in the literature. When it comes to allocation of multiple service departments' costs to operating departments, reciprocal method is posited by almost all authors to yield the most accurate results. The power of reciprocal method over other methods (direct method, step-down method) lies in its considering the mutual services provided among all service departments. That is costs of service departments are allocated to each service department (except the service provider) besides operating departments. However the application of this more powerful method is rare because it is more complicated than other methods and it requires sophisticated computer aid. This is even the case for some firms that use ERP software since this method requires additional modification in coding. Hence most of the companies employ either of direct or step-wise methods. While reciprocal method considers mutual services provided among all service departments, direct method and step-down method ignore this point. Moreover service department cost used by other service departments are also ignored in direct method. This drawback of direct method is partially reduced by step-down method by following a hierarchy among service departments while considering cost allocation.

While there is consensus over the superiority of reciprocal method over other methods, there is less evidence regarding the performances of alternative and more widely used methods like direct method and various applications of step-wise method. The first aim of the paper is to determine which method allocates service departments' costs to operating departments with regard to the allocation by reciprocal method by a simulation study. The second aim is to find out under which

*Corresponding author. E-mail: hakan.ozkaya@yasar.edu.tr.

conditions each allocation method yields the best results. To our knowledge Jacobs and Marshall (1999) were the first to document mean absolute relative errors of direct and step- down methods from reciprocal method and argued that the errors could be quite large and vary to a great extend however Christensen (2000) argue that they did not report standard deviations and did not provide evidence on the significance of the differences. Christensen (2000) filled this gap with about 500 random iterations and documented that step methods are significantly more accurate than direct method being step (percent) method is significantly more accurate than step (cost) method.

Our paper differs from that of Christensen (2000) in that we based our results on significantly higher number of random observations (that is, 10,000) which increased the robustness and the sensitivity of the results to a large extend. Secondly our paper took a further step to determine the probabilities that one can achieve the most and the worst accurate results by blindly choosing either of the methods. Last but not the least we analyzed the conditions under which these methods were superior to each other.

The paper provides another contribution to literature with its methodology. Because it is hard to find continuous and complete dataset regarding cost information of a specific firm, cost accounting literature mostly employs case study methodology. Case study methodology hinders the results to be generalizable but the results are peculiar to the investigated company. Generating random data under desired restrictions and with specific distribution characteristics by Monte Carlo simulation can be solution for the drawback of cost accounting area. The paper contributes to the literature by providing a decent example of using this rare methodology to overcome the difficulty of finding large cost accounting datasets.

The rest of the paper proceeds as follows: Section 2 provides a literature review and summarizes cost allocation methods, Section 3 describes the simulation methodology and the restrictions in generating variables, the analysis and main results are presented in Section 4 and finally Section 5 concludes with discussion of results.

LITERATURE REVIEW AND THEORETICAL FRAMEWORK

Indirect manufacturing departments and support departments are two distinct sources of companies' overhead costs. An organization's support activities include service and administrative departments. While service departments are organizational units like; central purchasing, maintenance, engineering, security, warehousing, etc., administrative departments are units like, human resources, accounting, legal, headquarters, etc. The costs of these support departments should be covered by products and services for appropriate cost computations, managerial motivation and managerial decision making. As the number of product lines and the complexity of organizations increased, the need for additional support activities also increased and appropriate allocation of support department costs became more vital for cost management (Barfield et al., 2001).

Costs accumulated in service departments can be allocated to operating departments by using either of four main methods, namely; direct method, step-down method, reciprocal method and planned allocation method. These methods are also used in allocating of costs accumulated in indirect manufacturing and administrative departments if the company has these departments (Yukcu, 2007). Being special cases of reciprocal method (Colins, 2003), direct method and step-down method are used throughout the paper for allocations.

When allocating the cost of service departments with direct method, only operating departments are considered and costs are not allocated among other service departments. On the other hand step- down method (also called sequential allocation method) does consider the inter allocations of costs among service departments but does not allocate each costs of service department costs to every of them. There is a ranking among service departments as to which department to begin allocation according to different rules which in turn yields different allocation figures. The drawback of step-down method to reciprocal method is that once the cost accumulated in the first in ranking service department is allocated, that department does not take any share from other service departments. The ranking is determined by two main rules in the literature. The first approach considers the number of departments served by the service departments to judge on which service department to begin allocation and which ones to move on. The service department that serves to the highest number of departments is the first department to begin allocation. In case of more than one department serve the highest number of departments, the department with highest accumulated costs is the first in the ranking and so on (Yukcu, 2007). We refer this application of step-down method as "STEP 1" in the paper. The second approach adopts the percentage of service in determining the ranking of service department to begin with and to carry on. The service department with highest percentage of service to other departments is the first in the ranking and so on. In case of more than one department with equal the highest service percentage, the one with higher accumulated costs is set as the first and so on (Horngren, 2006) . We refer this alternative application as "STEP2". What is common in both applications is that a service department does not take costs from itself even if there is a service percentage and once the department that is begun with in allocation process does not take share from other service departments (Yukcu, 2007).

Lastly reciprocal method (also called algebraic allocation method) (REC) considers all served departments including service departments and operating departments by a service department except the one whose costs are allocated. That is there is a two way interaction among service departments unlike step-down method. Since the method considers all the service departments to be allocated, the method yields equations with multiple unknowns which are equal to the number of service departments. As the number of service departments increase the number of equations with multiple unknowns increase and computer aid is required to solve the equations simultaneously (Yukcu, 2007).

It is easier to comprehend and apply the direct method and different applications of service departments, yet reciprocal method yields superior allocation results due to its consideration of two-way interaction between service departments. Thus reciprocal method is conceptually the most accurate method in allocations (Horngren, 2006; Yukcu, 2007) but accounting softwares or even ERP programs that are designed to employ reciprocal method and step-down method are rare. Direct method is the common default method for most of the softwares which makes it only choice for most of the companies. Research also shows that direct method is the one that is most widely used due its conceptual and practical simplicity. 43% of Australian firms and 58% of Japanese firms declare that they adopt direct method while 3% of Australian and 27% of Japanese firms adopt step-down method for allocating service department costs. Moreover in Australia 5% and in Japan 10% of the surveyed firms adopt reciprocal method while the rest of the firms declare that they do not allocate service department costs to operating departments (Blayney and Yokohama, 1991 in Horngren, 2006) . A more recent survey by Szychta (2002) documents that step-down method is the most widely used method by 14 out of 39 enterprises followed by reciprocal method by 12 out of 39 enterprises and 7 out of 39 enterprises use direct allocation method.

SIMULATION METHODOLOGY

A hypothetical manufacturing company with four distinct service departments and three distinct operating departments is used throughout the paper.[*] Operating departments of the hypothetical company are labeled as OD1, OD2 and OD3 and service departments are labeled as SD1, SD2, SD3 and SD4. Moreover service percentages which are used as the allocation bases in calculations are labeled as SRSP1, SRSP2, SRSP3 and SRSP4.

Accumulated costs in service departments and operating departments and the allocation bases which represent the percentage of services taken from service departments are generated randomly by “rand between” formula in MS Excel program which yields uniformly distributed random variables between certain upper and lower limits. The percentages of services for service departments are restricted to vary between 0 and 15% and for operating departments between 15 and 75%. We believe these uneven service percentages between service and operating departments reflect real life conditions because service departments exist to serve the operating departments in the first place and the service percentages among each other should be lower than those of operating departments. Moreover accumulated costs are restricted to vary between 0 and 1,000,000 TL. The lower and upper bounds of costs for service and operating departments are equal here but it makes no difference on the results since the costs for operating departments are not relevant variables in the calculations. This operation was repeated 10,000 times yielding a dataset with 10,000 different accumulated cost figures in service departments and 10,000 different allocation bases for them. The table which shows a single observation of the main dataset of the study and the restrictions of the variables are shown in Table 1.

While the solution for direct and step-down methods can be achieved by plain formulas in MS Excel, the solution for reciprocal method requires solutions of equations with multiple unknowns (four in this paper). The Solver tool of MS Excel was utilized for the solutions. [†, ‡]

While the reciprocal method (REC) which is advocated as the method to yield the most accurate results in the literature is used as the control variable, the direct method (DIR), the first application of step-down method (STEP 1) and the second application of step-down method (STEP 2) are the test variables of the study. The percentage deviation of the results of test variables (DIR, STEP 1 and STEP 2) from those of control variable, mean absolute deviation (REC) is the measure of the performance of the methods. The performance measure (MAD) is calculated as follows: since there are three operating departments of our hypothetical company, the deviations of results of the test variables from results of the reciprocal method is found for each operating department and the mean absolute deviation of three operating departments is calculated.

ANALYSIS AND RESULTS

Mean absolute deviations of results of test variables from results of reciprocal method and the ANOVA test results are presented in Table 2. Allocation results through the second application of step-down method (STEP2) showed the least deviation (0.89%) from reciprocal method while the first application of step-down method followed as the second best (0.93%) and finally direct method showed the highest deviation (1.01%) on average. Moreover the mean difference among mean absolute deviation results of the methods were highly statistically significant (F statistics = 76.005). When we consider multiple comparisons; we see that mean absolute deviation of STEP 2 is significantly less than DIR and STEP 1 and mean absolute deviation of DIR is significantly higher than both of STEP 1 and STEP 2. Results suggest that while STEP 2 yields most accurate results among alternative methods with regard to reciprocal method, DIR method yields the least accurate

[*] A numerical example of the hypothetical company which has support departments of maintenance, catering, utility and water supply, and operating departments of remelting, casting and lathe and produce automobile spare parts can be found in Yükçü (2007: pp. 254-266).

[†] Further information regarding utilization of Solver tool in solution of linear equations can be found in Alan and Ye ilyurt (2004).

[‡] Alternatively Franz (2007) provides a numeric example of using matrix algebra for solution of reciprocal method.

Table 1. Example of one observation of the dataset.

	SRSP1 (%)	SRSP2 (%)	SRSP3 (%)	SRSP4 (%)	Accumulated cost
SD1	(0-15)	(0-15)	(0-15)	(0-15)	(0-1.000.000) TL
SD2	(0-15)	(0-15)	(0-15)	(0-15)	(0-1.000.000) TL
SD3	(0-15)	(0-15)	(0-15)	(0-15)	(0-1.000.000) TL
SD4	(0-15)	(0-15)	(0-15)	(0-15)	(0-1.000.000) TL
OD1	(15-75)	(15-75)	(15-75)	(15-75)	(0-1.000.000) TL
OD2	(15-75)	(15-75)	(15-75)	(15-75)	(0-1.000.000) TL
OD3	(15-75)	(15-75)	(15-75)	(15-75)	(0-1.000.000) TL
Total	100	100	100	100	

Table 2. Mean absolute deviation results of the methods and ANOVA test results.

Dependent variable: mean absolute deviation					
	N	**Mean**	**Std. Dev.**	**F**	**Sig.**
Between groups				76.005	0.01
STEP1	10.000	0.937	0.687		
STEP2	10.000	0.891	0.635		
DIR	10.000	1.011	0.746		
Total	30.000	0.946	0.692		

Multiple comparisons

Dependent variable: mean absolute deviation

Bonferroni

(I) Method	**(J) Method**	**Mean difference (I-J)**	**Std. Error**	**Sig.**
STEP 1	STEP 2	0.045	0.010	0.01
	DIR	-0.074	0.010	
STEP 2	STEP 1	-0.045	0.010	0.01
	DIR	-0.119	0.010	
DIR	STEP 1	0.074	0.010	0.01
	STEP 2	0.119	0.010	

results.

The probabilities of yielding the most and the least accurate results obtained by the methods are shown in Table 3. While the second application of step-down method (STEP 2) yielded the best allocation in 3,709 out of 10,000 observations, the figures were 3,482 out of 10,000 for the first application of step- down method (STEP 1) and 3,412 out of 10,000 for the direct method (DIR). In 603 out of 10,000 observations STEP 1 and 2 yielded the best results together which occurred coincidentally due to the same ranking obtained by different rules of the methods. Moreover direct method yielded the worst results in 4,009 out of 10,000 observations, the first application of step- down method (STEP 1) yielded the worst results in 3,352 out of 10,000 observations and the second application of step-down method (STEP 2) yielded the worst results in 2,943 out of10,000 observations. Again in 304 observations STEP 1 and STEP 2 together yielded the worst results coincidentally. Results show that while STEP 2 gave the most accurate results with the highest probability (37.09%) and the least accurate results with the least

Table 3. Probabilities of best and worst allocation results by methods.

	The most accurate		The least accurate	
	No. of obs.	**Prob. (%)**	**No. of obs.**	**Prob. (%)**
STEP 1	3.482	34.82	3.352	33.52
STEP 2	3.709	37.09	2.943	29.43
DIR	3.412	34.12	4.009	40.09

Table 4. Multiple comparisons of the most accurate results yielding methods.

Multiple comparisons				
Dependent variable: Percentage of service taken from Service Departments				
Bonferroni				
(I) Method	**(J) Method**	**Mean difference (I-J)**	**Std. Error**	**Sig.**
STEP 2	STEP 1	-0.263	0.078	0.01
	DIR	-0.198	0.075	
Multiple comparisons				
Dependent variable: Costs accumulated in Service Departments				
STEP1	STEP 2	-58.999.610	14.615	0.01
	DIR	-179.546.854	14.296	
STEP 2	STEP 1	58.999.610	14.615	0.01
	DIR	-120.547.244	14.010	
DIR	STEP 1	179.546.854	14.296	0.01
	STEP 2	120.547.244	14.010	
Multiple comparisons				
Dependent variable: Percentage of costs accumulated in Service Departments				
STEP 1	STEP 2	-0.829	0.294	0.01
	DIR	-2.547	0.288	
STEP 2	STEP 1	0.829	0.294	0.01
	DIR	-1.718	0.282	
DIR	STEP 1	2.547	0.288	0.01
	STEP 2	1.718	0.282	

probability (29.43%), DIR gave the least accurate results with the highest probability (40.09%) and the most accurate results with the least probability (34.12%) which suggest that superiority of STEP 2 over alternative methods.

As mentioned above, each method yielded the most accurate results in some of the observations. Our next analysis was directed towards determining which method yielded the most accurate results under which conditions. We ran several ANOVA tests with different dependent variables which we thought might have been the cause for the superiority of each method over other methods and checked whether the methods differed significantly on specific dependent variables while being superior over other methods. Table 4 presents multiple comparisons of methods with different dependent variables which were found to be the underlining dynamics of the superiority. Only the significant results were presented for the ease of presentations.

Results indicate that the dynamics affecting methods superiority over each other are; the percentage of service taken from service departments, cost accumulated in service departments and percentage of costs accumulated in service departments in total costs. STEP 2 yielded the most accurate results when the percentage of service taken from service departments are significantly lower, STEP 1 yielded the most accurate results when the costs accumulated in service departments and the percentage of costs accumulated in service departments are significantly lower and DIR yielded the most accurate

results when costs accumulated in service departments and the costs accumulated in service departments are significantly higher.

Conclusion

This paper compared the performances of different allocation methods of service departments to operating departments by a Monte Carlo Simulation. Based on the results we can say that one can get the most appropriate allocation results on average if he or she employs the second application of step- down method in allocation of service department costs to operating departments. Likewise one should avoid employing direct method over alternative step-down methods since he or she gets the least appropriate results on average. Moreover the probabilities of obtaining the most accurate results differ with regard to certain conditions. As the percentage of services taken from service departments increase, the second application of step-down method (STEP 2) more likely gives the most accurate allocation results and as the costs and the percentage of costs accumulated in service departments increase direct method more likely gives the most accurate results and as they decrease the first application of step-down method (STEP 1) more likely gives the most accurate results.

One can argue that while the differences between mean absolute deviations, that varies between 0.04 and 0.11%, statistically significant, they do not seem economically significant at all. This would be a fallacy because it should be kept in mind that costs accumulated in service departments could be more than dozens of millions according to the size of the company which would mean a misallocation of between 40,000 and 100,000 TL per 10,000,000 TL to operating departments. Thus, the results of the study are both statistically and economically significant.

The results of the study provide new knowledge for both academic literature and for cost accounting practitioners. First it provides a decent reference for cost accounting textbooks which list and explain cost allocation methods like direct method and step-down methods with numeric examples but fail to posit the superiority of these methods over each other. Given the fact that compared methods are the ones that are employed most widely by cost accounting practitioners, the second contribution of the paper is that it guides the practitioners as to which method to employ under certain circumstances. Practitioners are introduced an objective comparison method like the one applied in the paper. They can re-run the simulation of the paper according to their production structures and restrictions and find out which method suits best for their companies and thus achieve more reliable cost allocation results. As the transfer pricing becomes widespread in manufacturing industry as an organizational performance evaluation system, more reliable allocation of costs among operating departments should mean a lot for the managers.

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