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Lattice allocations: A better way to do cost allocations

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ABSTRACT

This paper describes a new cost allocation technique that we call "lattice allocation." The technique uses matrix algebra operations such as in standard spreadsheet software to perform complex cost allocations. To illustrate the power and versatility of the technique, we provide two examples. First, we show how lattice allocations can allocate service department costs to fully recognize mutual services among service departments, similar to the reciprocal method but without the complexity of solving a set of linear equations. Second, we show how lattice allocations can implement two-stage activity-based costing in a single step. The lattice allocation method is easy to apply, requires no special software for small organizations, easily scales up to medium and large organizations, and provides managers better information about the origins of allocated costs. Also, lattice allocations are likely to produce more accurate results than traditional techniques and are well-suited as a pedagogical tool for cost accounting courses. The paper suggests future research topics, including the implications of lattice allocations for Fast Close, Continuous Reporting, and government contractor cost accounting requirements.

1. Introduction

We introduce a new method, "lattice allocation," for computing cost allocations. We illustrate the method first for service department cost allocations, and then for two-stage activity-based costing. The technique is quite different from methods currently used, and has significant advantages over them. The lattice allocation method (LA) uses matrix algebra operations such as in standard spreadsheet software to perform complex cost allocations, thereby making sophisticated costing methods accessible to organizations of all sizes, as well as for pedagogical purposes.

There are four important advantages of LA over current methods. First, LA is easy to learn and easy to implement. The user creates a single matrix that shows the allocation rules, runs a simple matrix manipulation, and the transformed matrix provides the user the percentages of the cost category (e.g., service department or cost pool) to allocate to each cost object (e.g., production department or product). The allocation rules only reflect allocations from each service department, and individually contain no information about downstream re-allocations. A single matrix can handle multi-stage allocations, such as allocating from cost categories to cost pools and then to products.

The second advantage of LA is that it is less prone to error. LA produces none of the errors inherent in the use of the direct and step-down methods. Because LA is simple, errors are less likely to be made, easier to detect, and easier to correct. An error in a particular service department allocation rule can be corrected without reference to the allocation rules in the other service departments. Also, some types of errors are easier to correct. For example, when LA is used for service department reciprocal cost allocations, if a service department discovers additional department costs that should have been allocated, there is no need to revise the matrix or rerun the matrix transformation. As long as the measures of usage by downstream departments are unchanged, the percentages in the transformed matrix are still correct. These percentages can be applied to the revised department cost total. Importantly, there is no need to revisit the allocations from the other service departments.

The third advantage of LA is that it highlights for downstream managers (e.g., product managers or production department managers) precise information about the original source of the costs allocated to them. For example, in two-stage activity-based costing where costs originate in cost categories, are allocated to cost pools, and then to products, LA provides the product manager the costs allocated from each cost category, not the total from the intermediate cost pool. If the same cost category is allocated to multiple cost pools and then to products, the product manager sees the total costs allocated from the cost category summed across all cost pools. This information has the potential to focus the product manager's efforts on cost reduction at the source, and away from efforts to shift costs in the cost pool to other

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product managers. A recent survey of management accountants identified cost reduction as their top priority, followed by generating cost information (Clinton & White, 2012). Lattice allocations are well-suited to helping organizations address both priorities.

The fourth advantage of LA is that it scales well, from the smallest classroom problem to the largest industrial problem. What students are taught can be directly applied in practice.

The lattice allocation method is an entirely new technique for allocating costs in accordance with the underlying provision of services. It is not a new principle of where costs should fall. Lattice allocations can be beneficially applied to any type of allocation, but it is most beneficial when current methods for implementing the allocation are complex, such as when there is a hierarchy of allocations (as in two-stage activity-based costing) or when there are reciprocal relationships (as often occurs in service department cost allocations). Although matrix algebra is currently used in some cost allocation applications, LA uses matrix manipulations in an entirely novel way, and by doing so, generates information that is not available from existing techniques.

The next section of the paper illustrates lattice allocations in the context of service department cost allocations. Section 2 applies LA to a relatively simple example drawn from a leading cost accounting textbook. Section 3 provides a step-by-step overview of lattice allocations. Section 4 applies LA to a more complicated service department cost scenario involving four service departments and three operating departments. Section 5 illustrates lattice allocations for two-stage activity-based costing. Section 6 provides concluding remarks.

2. Service department costs: example 1

There are currently three common methods for allocating service department costs: the direct method, the step-down method, and the reciprocal method. Of these three techniques, only the reciprocal method recognizes all services provided by service departments to other service departments. Thus, it is the most accurate method of allocating service department costs, but it is also the most complicated. According to Zimmerman, "while the reciprocal allocation method has certain theoretical advantages, it is not widely used" (Zimmerman, 2014, 345). Christensen and Schneider (2017) note that "often the prospect of allocating service department costs can lead to feelings of frustration or dread in accounting practitioners or students" (51).

There are several ways to apply the reciprocal method (Keller, 2015). One method solves a set of simultaneous equations using algebraic substitutions. Another way uses a matrix approach for solving these simultaneous equations. The algebraic substitution method becomes unwieldy as the number of service departments increases. Hence, many cost accounting textbooks illustrate the reciprocal method using just two service departments and two production departments, similar to the example in Horngren, Datar, and Rajan (2012) used below. The matrix approach works for a more realistic number of service and production departments, but requires a level of mathematical ability beyond skills typically possessed by accounting students or even many practitioners. Concerning use of matrix methods for traditional allocation methods, Christensen and Schneider (2017) recently observed "students and financial managers find the use of matrix algebra to be quite a challenge" (52). Christensen and Schneider (2017) illustrate how Excel can be used to facilitate implementation of a third method for deriving reciprocal cost allocations, the iterative method. This method is easier to explain than the matrix approach, but also becomes unwieldy when there are numerous service departments. We present another way to allocate service department costs that captures the reciprocal relationships among service departments. Our method uses matrix algebra, is fundamentally different from matrix methods described in the literature, but obtains results identical to those methods.

We start with the example from Horngren et al. (2012, 550–557). A firm has two service departments, Maintenance and Information Systems (IS), and two production departments, Machining and Assembly. The support departments provide services to the production departments and to each other. Each support department tracks which departments receive its services and in what proportions.

Table 1
Example 1 – intrinsic rules.

	Maintenance	IS	Machining	Assembly
Maintenance	0.00	0.20	0.30	0.50
IS	0.10	0.00	0.80	0.10
Machining	0.00	0.00	1.00	0.00
Assembly	0.00	0.00	0.00	1.00

For Maintenance, 20% of its services are provided to IS, 30% are provided to Machining, and 50% are provided to Assembly. For IS, 10% of its services are provided to Maintenance, 80% are provided to Machining, and 10% are provided to Assembly. In the terminology of Lattice Allocations, these two sentences describe the "intrinsic" rules of the problem. Table 1 provides a comprehensive description of these intrinsic rules:

Some points to note:

1. The percentages have been restated to fractions.
2. Each row sums to one.
3. Production departments are shown as allocating 100% to themselves.
4. The information in Table 1 can be obtained from each service department, based on that department's information about services it provides to other departments, without requiring any information about subsequent downstream re-allocation.

We refer to the 4 × 4 matrix of fractions in Table 1 as the Lattice Allocation matrix. The central technique of LA is to multiply this matrix by itself until the transformed matrix converges to a stable solution and final rules emerge. In other words, one takes this matrix to a sufficiently high power to obtain the desired degree of accuracy for the organization's costing purposes. Simply squaring the matrix often provides the desired accuracy. When the LA matrix in Table 1 is squared, the result is the matrix of percentages (rounded to two decimal places) shown in Table 2.

The matrix in Table 2 can be partitioned into quadrants. The four cells in the upper-left quadrant represent services provided by each service department to the other service department. The four cells in the upper-right quadrant represent services provided by each service department to the production departments. The eight cells in the lower quadrants reflect the fact that no costs are allocated out of the production departments. Going from Tables 1 to 2, the total amounts allocated in the upper-left quadrant are reduced, the amounts allocated in the upper-right quadrant have increased, and there are no changes in the lower quadrants. Each row continues to sum to one. These characteristics are always true in the Lattice Allocation method.

Table 3 reports the results of the LA matrix taken to the third power (i.e., Table 3 multiplies the matrix in Table 1 by the matrix in Table 2), rounded to two decimal places.

In Table 3, the amounts in the upper-left quadrant have been reduced to zero, while the amounts in the upper-right quadrant sum to

Table 2
Example 1 – the squared matrix.

	Maintenance	IS	Machining	Assembly
Maintenance	0.02	0.00	0.46	0.52
IS	0.00	0.02	0.83	0.15
Machining	0.00	0.00	1.00	0.00
Assembly	0.00	0.00	0.00	1.00