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THE NEW MANUFACTURING ENVIRONMENT REQUIRES A NEW COST ACCOUNTING SYSTEM

Bruce Mead Serchuk

Introduction

Bob Jones is the controller for the Realcool Refrigerator and Appliance Corporation. In preparation for the company's annual meeting, Bob and his staff have prepared a report on the profitability of their current line of products. Bob is very distressed to find that the company's most popular refrigerator, the Excalibur, appears to be unprofitable. He recalculated the gross margin for the Excalibur and found no errors in his staff's work; so he presented the information, as is, at the annual meeting. No one present could understand how a refrigerator that had for so long been the principal product of the Realcool line could suddenly be losing money.

For the Realcool Refrigerator and Appliance Corporation, the manufacturing process used in its factories has changed. While in the past the product was manufactured almost entirely by hand, today automation allows a majority of the work to be done by machines. For example, the cost of painting a refrigerator formerly consisted of paint and labor. Today, the paint is applied by an automated robot. Unfortunately, while the manufacturing process has changed, firms' accounting systems have not moved along with the technology.

Was that refrigerator really too costly to produce or had Realcool's accountant set up a cost system which distorted the true cost? Have changes in today's manufacturing environment caused the accountant's cost accumulation systems to be somewhat archaic? The answer to both of these questions is yes. The new manufacturing technology is having a profound effect on various aspects of accounting.

The purpose of this paper is to focus on two specific consequences of the changes in the manufacturing environment: how this new environment affects the manner in which overhead costs are attached to the products being produced and how a misallocation of these costs can cause decision making to be inaccurate. Following the discussion of the effects of the new manufacturing environment, various solutions to the problems will be proposed,
along with a brief caution against what might appear to be a simple, obvious answer.

**Manufacturing Overhead: A Special Problem**

Before the problem of the misallocation of overhead and its effect on decision making is addressed, it is important to first present some background concerning the application of the costs of manufacturing to products.

In the manufacture of a refrigerator (or other products for that matter), there are three types of manufacturing costs that must be considered:

1. **Direct material costs**—acquisition costs of all materials that are identified as part of the finished goods and that may be traced to the finished goods in an economically feasible manner.
2. **Direct labor costs** (hereafter “direct labor”)—wages of all labor identifiable with the production of finished goods and which like direct materials can be traced to finished goods.
3. **Manufacturing overhead**—all costs other than direct materials and direct labor associated with the manufacturing process (Horn gren, pp. 953–955).

It is important to note two distinctions between overhead and the other manufacturing costs. First, manufacturing overhead is an indirect cost—that is, one that cannot be easily traced to a specific product. This difficulty exists because it is too costly to determine the amount of the input used or time spent (like the paint sprayed onto a refrigerator), or because the overhead is not specifically related to the actual production. Examples of overhead not specifically related to production are a janitor’s salary or the depreciation on machinery in the factory. In contrast, materials and labor costs, which are direct costs, can be easily linked to the product. Examples of these would be the sheet metal used or the time spent by a worker in assembling all of the components of a refrigerator. A second distinction between the two types of costs is that manufacturing overhead is predominantly a fixed cost, and is relatively insensitive to changes in volume. Direct costs, on the other hand, vary with changes in volume.

It is at this point that the problems begin. How does the firm apply manufacturing overhead, which is again primarily fixed, to the various products so that each bears a fair share of the costs? The firm cannot simply allocate the actual costs equally to each product due to three problems related to overhead allocation. First, the time to produce the different items may vary. For example, one refrigerator model might require twice as many hours to complete as another model. Second, certain indirect costs might vary in amount throughout the year. For example, what if heating costs were higher during one part of the year than another? Should those products produced during the colder weather bear a disproportionate share of the costs? Lastly, the volume of production of a particular good might be greater during one season than in another. Should the goods produced during the former time period receive a smaller portion of the indirect costs simply because the quantity produced is greater?

To attach manufacturing overhead to products, a cost allocation base must first be selected. This base should be one which can be somehow linked to the products being manufactured and to the incurrence of the overhead. Examples of allocation bases are direct labor hours, direct labor cost, and machine hours. After a base is chosen, the budgeted overhead figure is divided by the budgeted base to give a predetermined overhead rate. Throughout the year, costs are applied to the products by multiplying this predetermined overhead rate by the amount of the selected base for the specific time period or production run. At the end of the year, if there is a difference between the actual overhead costs and the applied overhead, this amount is either written off to the cost of goods sold, or, if sufficiently large, allocated to the work-in-process inventory, finished goods inventory and cost of goods sold.

**Overhead Takes on a New Significance**

In the past, manufacturing overhead has comprised only a small portion of the total manufacturing cost (Dhavale, p. 41). Direct
materials cost was the largest component of product cost, but direct labor was still a substantial cost element. Because direct labor was such a significant cost factor and because labor figures, such as hours spent or dollars expended, were accumulated for external accounting purposes, direct labor hours or direct labor dollars were the most commonly used allocation bases in the application of overhead.

Over the years, however, production processes have changed. Direct labor is generally no longer a large portion of the cost of production. In a recent survey of 2000 users and preparers of management accounting information, the respondents said that manufacturing costs, on average, consist of 53 percent material, 15 percent direct labor, and 32 percent overhead costs (Howell, p. 39). With the increased automation of factories and the use of numerical control machines, this trend will most likely continue. Unfortunately, many accountants have not modified the cost accumulation systems to take this trend into account. They have overlooked the fact that selecting an alternative base would have a significant effect on cost allocations. Also, they may not realize that the cost of switching bases is often small compared to the benefit of improved accuracy of product costing.

Imagine a situation where a factory has two equally sized departments, each producing the same refrigerator. One of these departments has been completely automated and has only 5 workers. The other department has not been automated and has 40 workers on a full shift. If the company uses direct labor hours to apply the overhead costs, the department that has been automated will bear one-ninth of the overhead, with 5 of 45 workers in the factory, while the product being manufactured is the same. What would happen if a job had no direct labor at all? If direct labor is the allocation base, then no overhead would be allocated to this department (Bennett, p. 10).

In the new manufacturing environment, a second problem of overhead allocation exists. Because direct labor hours are such a small component in the production process, using it as an allocation base leads to an extremely high predetermined overhead rate. This in turn leads to variability in the amount of costs that are applied to products and thus the possibility of extreme distortion. If one production line uses slightly more direct labor hours than another line because of the large predetermined overhead rate, there would be a large difference in the amount of overhead cost that each of the lines would have to bear.

Because this very small component of cost, direct labor, is being used as a basis for applying a larger overhead cost, it is not unusual to see thousands of dollars of industrial engineering time devoted to saving literally tenths of hours of direct labor time (Johnson and Kaplan, p. 188). Management believes that by reducing the direct labor hours it can reduce the cost of manufacturing a particular product. This is due to the large change in overhead allocation that follows a small reduction in direct labor hours. Unfortunately, because direct labor is already such a small component of cost, the amount of funds and engineering time necessary to reduce direct labor hours will most likely exceed the cost savings received.

Given today's levels of technology, the real problem is that there is little if any causal relationship between direct labor and the indirect expenses (Brunton, p. 25). Most of the new indirect costs are linked in some other way with the machinery involved with current methods of manufacturing. For example, the advent of automation has meant that the following costs, all of which are unrelated to direct labor, have now become a much larger portion of overhead:

1. Depreciation on machines
2. Out-of-pocket costs to keep the machines running
3. Machine support, such as programmers and engineers.

Not only is the composition of overhead increasingly unrelated to direct labor, but it is also the case that overhead is becoming increasingly difficult to identify and assign to jobs (Dhavale, p. 42). With automation and the use of numerically controlled machines, it is not unusual for one machine operator to supervise more than one machine, with each machine producing different units in varied lot sizes. This person's time would be difficult to allocate
to the units of the machines he supervises, and thus certain products might receive more or fewer hours than they may have actually taken to manufacture. This would in turn lead to an incorrect amount of overhead being applied to each.

The shortcomings of direct-labor-related allocation bases suggest that they may have to be replaced. While in certain manufacturing situations direct labor may be a small cost component, this same problem could arise with any allocation base. When the cost related to an allocation base becomes too small a portion of the total cost to manufacture or becomes difficult to identify with specific products, its usefulness becomes questionable. At this point, the company must reevaluate its current base and examine possible substitutes.

**Overhead Allocation and Product Profitability**

What effects do the problems involving overhead allocation have on the company's decision as to whether to continue producing a particular item? Certainly this decision is contingent upon the product's profitability. For the purposes of this article, profitability will be based on whether the product's gross margin is positive. Gross margin is defined as the sales of a product less its cost of sales. The cost of sales includes the three manufacturing costs: material, labor and overhead.

Ordinarily, the concept of contribution margin is used instead of gross margin in short-run decision making, with contribution margin defined as product sales less variable production costs. Contribution margin would be appropriate because in the short-run a firm must cover its variable costs to remain in business. However, in the long-run, it is not sufficient for a firm to cover its variable costs; all costs must be covered for a firm to be profitable. Thus, the use of gross margin as a measure of profitability is justifiable.

In the measurement of profitability, overhead misallocation can cause problems in the decision making process. The firm might use a markup-on-cost method for setting prices, ignoring the possibility that the cost is distorted and the effect this would have on the price.

This could make the product appear profitable when it is not. However, if the price calculated from the cost is above that for similar goods, the product will not sell. This pricing problem can be eliminated if the selling price is based on competitors’ prices rather than a markup on cost. However, the distorted cost would still affect the computation. When it is subtracted from the market price, the gross margin calculated might be at a level undesirable to management. In fact, the product may or may not be profitable, but the distorted cost calculation conceals this.

In summary, if a product has more cost allocated to it due to an overhead misallocation, it will not appear as profitable as perhaps it should. Managers have said that some profitable product lines have been dropped because overhead allocations made them appear unprofitable (Bennett, p. 9). Conversely, an unprofitable line might be kept because it incorrectly appeared to be making money. A numerical example might clarify these points.

Consider two types of refrigerators, Alpha and Beta, each being produced using different levels of technology. Refrigerator Alpha is manufactured using automated manufacturing technology. Refrigerator Beta is produced by a different technology, one requiring mostly direct labor hours. In the example, it will be assumed that selling prices are set externally.

In order to determine the profitability of each product, it is necessary to compute the overhead per unit. For this, the following calculations must be made:

1. The hours per unit, as given in Table 1, for both bases must be multiplied by the production in units (100,000 for each type of refrigerator) to give total machine hours and direct labor hours for the budgeted production.
2. The total overhead ($30 million) is divided by the total budgeted hours for each production method to give the overhead rate per machine hour and direct labor hour (both $60.00).
3. To calculate the overhead cost per unit using either allocation base, the overhead rate ($60.00) is multiplied by the hours per unit, either machine hours
Table 1
Comparison of the Profitabilities of Two Refrigerators

<table>
<thead>
<tr>
<th>Refrigerator</th>
<th>Alpha</th>
<th>Beta</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Machine Hours/Unit</td>
<td>4</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Direct Labor/Unit</td>
<td>1</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Machine Hours/Total</td>
<td>400,000</td>
<td>100,000</td>
<td>500,000</td>
</tr>
<tr>
<td>Direct Labor/Total</td>
<td>100,000</td>
<td>400,000</td>
<td>500,000</td>
</tr>
<tr>
<td>Total Overhead Cost</td>
<td>$30,000,000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Overhead Rate</td>
<td></td>
<td>$60.00</td>
<td></td>
</tr>
<tr>
<td>Per Machine Hour</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Per Direct Labor Hour</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Gross Margin/Unit—Using Machine Hours as the Allocation Base

| Selling Price | $650.00 | $500.00 |
| Direct Material | $400.00 | $250.00 |
| Direct Labor    | $100.00 | $150.00 |
| Manufacturing Overhead | $240.00 | $60.00 |
| Gross Margin    | ($90.00) | $40.00 |

Gross Margin/Unit—Using Direct Labor Hours as the Allocation Base

| Selling Price | $650.00 | $500.00 |
| Direct Material | $400.00 | $250.00 |
| Direct Labor    | $100.00 | $150.00 |
| Manufacturing Overhead | $60.00 | $240.00 |
| Gross Margin    | $90.00 | ($140.00) |

or direct labor hours, for each product. For example, for refrigerator Alpha the manufacturing overhead per unit for machine hours would be the product of the $60.00 overhead rate and the four machine hours required to make the product—or $240.00 overhead per unit.

From Table 1, it becomes clear that the profitability is highly dependent upon how the overhead is handled. It is important to notice that if the allocation bases are switched, the gross margins of both refrigerators change drastically. If machine hours are used, refrigerator Beta would be profitable to produce; but with direct labor hours, refrigerator Alpha would be profitable. The point again is that the use of different bases can lead to different conclusions with respect to a product’s profitability.

Improving the Allocation Process

It is quite evident that the problem with the allocation of manufacturing overhead can-
not be ignored. However, this misallocation of costs may not affect all firms. In seeking to determine if a problem exists, a firm should first address two questions:

1. Does the firm use a new or recently updated method of production, characterized for example by a highly automated assembly line or by the use of robotics?

2. If so, then does this firm account for product costs in the same manner as before the new technology was implemented?

If the answer to each of these questions is yes, then there is a good possibility that the firm is not properly accounting for its overhead costs. There are several actions that a company can take to either improve the allocation process or to choose an appropriate allocation base.

**Department Rates, not Plant-wide Rates**

One simple solution is for the firm to consider using department rates rather than a single plant-wide rate. In Table 1, a plant-wide rate was used. Using such a rate, there was one predetermined overhead rate used for the entire factory, regardless of the existence of multiple products and multiple departments. The plant-wide rate is used primarily because of the simplicity of computation. If a departmental rate had been used, there may have been a different rate for each department.¹

The use of department overhead rates has two distinct advantages over a single plant-wide rate. First, department rates eliminate problems created by averaging different departments or lines. In the example presented in Table 2, the budgeted machine hours for departments A and B are equal; but because of the different amounts of overhead present in each, the predetermined overhead rates are different. However, with the use of a plant-wide overhead rate, a single average rate between the two departments would be used. If the single rate is used in decision making, the products in both departments would receive a distorted amount of overhead, which could lead a manager to misjudge relative product profitability (Horn gren and Foster, p. 447).

A second advantage of the use of departmental rates is that multiple allocation bases can easily be used. As mentioned previously, a situation might exist where two departments, each producing refrigerators, nonetheless use different technologies. However, a plant-wide rate can use only one base. With departmental rates, two different bases could be used, with each department using a base appropriate to its own manufacturing technology. Refrigerators built manually could be assigned overhead costs based on direct labor hours, and those produced by machines could be assigned indirect costs based on machine hours (Brunton, p. 23).

There is one drawback which should be noted concerning the use of departmental rates, and that is the additional time and money which may be necessary for the generation of the required data. To determine if this additional cost is justified, a cost-benefit test should be applied. It should be determined if the allocations using departmental rates differ significantly from those using a plant-wide rate. If the departmental rates deliver a cost savings greater than the additional time and money expended, then the use of the more detailed information

### Table 2

Comparison of a Plant-wide Rate and Departmental Rates

<table>
<thead>
<tr>
<th></th>
<th>Department A</th>
<th>Department B</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Budgeted Overhead</td>
<td>$10,000</td>
<td>$2,000</td>
<td>$12,000</td>
</tr>
<tr>
<td>Budgeted Machine Hours</td>
<td>1,000</td>
<td>1,000</td>
<td>2,000</td>
</tr>
<tr>
<td>Overhead Rate</td>
<td>$10.00</td>
<td>$2.00</td>
<td>$6.00</td>
</tr>
</tbody>
</table>

¹Another alternative to plant-wide rates is the use of a product line rate, in which each line within a department would have its own allocation base. Such a rate has the same advantages and disadvantages as the departmental rate.
pass the cost-benefit test. Conversely, if the information does not show significant differences, then a plant-wide rate should be retained because in the long run it will be less costly and lead to substantially the same decisions.

Department rates have gained popularity in recent years. In a 1988 survey of Fortune 500 controllers, 61 percent indicated that they use departmental rates in some of their plants. However, 20 percent use multiple plant rates and 39 percent use an individual plant rate in their manufacturing facilities (Hendricks, p. 25). As we have seen, the use of plant-wide rates causes firms to apply costs in a distorted manner, which in turn can lead to poor decision making.

Selecting an Appropriate Base

If department rates are used, the firm can accommodate situations in which multiple levels of manufacturing technology exist. In the determination of the optimal base for these situations, firms should attempt to find a base with the following characteristics:

1. One which exhibits a high correlation with the level of indirect expenses, i.e. where the base causes overhead to change.
2. One which is easy to implement and measure.
3. One which is common to all jobs or activities.

If the firm can find such a base and the cost to implement the base does not outweigh the cost savings, it will most likely improve product costing and decision making.

One way to choose an appropriate base is through the use of linear regression. From the cost accounting standpoint, linear regression is a method of cost estimation in which the mathematical criterion of least squares is used to fit a linear equation through accumulated data on an allocation base and cost figures (Morse and Roth, p. 975). Through the use of linear regression, the relation between a given allocation base and cost can be determined. By accumulating data for various potential bases the company can choose the allocation base with the highest degree of correlation between the base and total overhead cost.

Linear regression can provide the firm with excellent information on various allocation bases. However, due to the high cost of accumulating data for many different activity bases, the entire process is not a cheap one. Because of this high cost of data collection, linear regression has not gained popularity in the corporate environment.

A second approach for selecting an allocation base is to distinguish between the long-run and short-run costs. The firm first splits all costs into a number of pools, which might consist of a machine, a group of machines or an entire department (Cooper, part 2, p. 41). Once this is done, the firm then separates the costs within a particular pool into long- and short-run components, since these two types of cost may be influenced by different activity bases. Short-run costs (e.g. direct materials) may be affected by volume, while long-run costs (e.g. inspection costs) may vary with the number of transactions. Because different activities cause the long- and short-run costs to change, it is appropriate to match the cost with its influencing activity base. For the short term, the firm can continue to use such typical bases as direct labor hours and machine hours. For the long term costs, the transactions taken on by the support departments in which these long-run costs are incurred prove to be useful as allocation bases. Some of these bases and the costs which they "drive" are (Cooper, part 2, p. 43):

<table>
<thead>
<tr>
<th>Allocation Base</th>
<th>Cost Driven</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Production runs</td>
<td>1. Inspection, setup cost</td>
</tr>
<tr>
<td>2. Shipments</td>
<td>2. Goods receipt, setup cost</td>
</tr>
<tr>
<td>3. Orders</td>
<td>3. Handling costs of raw materials, work-in-process and finished goods</td>
</tr>
</tbody>
</table>

Because the firm already accumulates these "cost drivers" for other purposes, the measure-
ment associated with the bases is low. Furthermore, instead of one type of base being used for all expenses, with the “transaction approach” (see Johnson and Kaplan) each type of cost is allocated with an appropriate base—that is, one that causes the cost to change.

**Should Direct Labor be Scrapped?**

From the preceding discussion, it might appear that direct labor hours should no longer be used as an allocation base and that machine hours should instead become the standard allocation base. The use of machine hours may seem like a logical solution, as automation becomes the predominantly used manufacturing technology. This, however, is not necessarily so because the change from direct labor hours to machine hours will not always deliver improved product costing.

For example, an increase in the ratio of machine hours to direct labor hours might at first seem to indicate that a switch to a machine-hour base would be in order. But if the ratio between the two bases remains the same from department to department, then the overhead allocation will also be the same no matter which base is used.

Neither would the assignment of an operator to run more than one machine necessitate a switch to machine hour costing. Rather it would depend on the ratio of machine hours to direct labor hours for the various products. If the ratio is constant across the products, then there again would be no need to change.

However, if the number of machines run by an operator or the number of operators running a single machine varies with the products, the ratio of machine hours to direct labor hours will not be constant. If the operator supervises the manufacturing of more than one product, with a varying amount of time spent on each, the ratio will also vary. In summary, if there is variation in the ratio of machine hours to direct labor hours, then the use of a machine hour base is justified. Unfortunately, management is sometimes too eager to switch bases when in certain situations the cost allocation would remain the same.

**Conclusion**

In the new manufacturing environment, production methods have changed. Today, many goods are manufactured by highly advanced machinery as firms strive to maintain or improve their competitiveness. For example, in a recent survey of a group of Fortune 500 controllers, 74 percent said they used robots and 68 percent said they had automated assembly lines in their manufacturing processes (Hendricks, p. 25). As manufacturing methods change, so do the types of costs and, more importantly, the composition of the costs. Because of the additional capital items necessary with the new methods of production, manufacturing overhead now comprises as much as 30–35 percent of total cost. At the same time, direct labor has been reduced to about 15 percent of total cost of production for most manufacturing firms.

Unfortunately, not all companies have realized that these new production methods often require new accounting methods. By using plant-wide rates and unrelated allocation bases, many firms are applying costs in a distorted manner, which in turn leads to poor decision making. Companies must begin to consider using departmental overhead rates and more appropriate allocation bases so that overhead can more accurately be applied. More accurate product costing is not out of reach for most manufacturing firms. All they must do is recognize that the new manufacturing environment requires a new cost accounting system.
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