Activity-Based Costing

CHAPTER 4

AFTER STUDYING THIS CHAPTER, YOU SHOULD BE ABLE TO:

1. Describe the basics of plantwide and departmental overhead costing.
2. Explain why plantwide and departmental overhead costing may not be accurate.
3. Provide a detailed description of activity-based product costing.
4. Explain how the number of activity rates can be reduced.
5. Describe activity-based system concepts including an ABC relational database and ABC software.

In Chapter 2, we mentioned that cost management information systems can be divided into two types: functional-based and activity-based. The functional-based costing systems use traditional product cost definitions and use only unit-based activity drivers to assign overhead to products. This chapter begins by describing how functional-based costing is used for computing traditional product costs. This enables us to compare and contrast functional-based and activity-based costing approaches. An activity-based cost accounting system offers greater product costing accuracy but at an increased cost. The justification for adopting an activity-based costing approach must rely on the benefits of improved decisions resulting from materially different product costs. It is important to understand that a necessary condition for improved decisions is that the accounting numbers produced by an activity-based costing system must be significantly different from those produced by a functional-based costing system. When will this be the case? Are there any signals that management might receive which would indicate that functional-based costing is no longer working? Finally, assuming that an activity-based cost accounting system is called for, how does it work? What are its basic features? Detailed features? What steps must be followed for successful implementation of an ABC system? This chapter addresses these questions and other related issues.

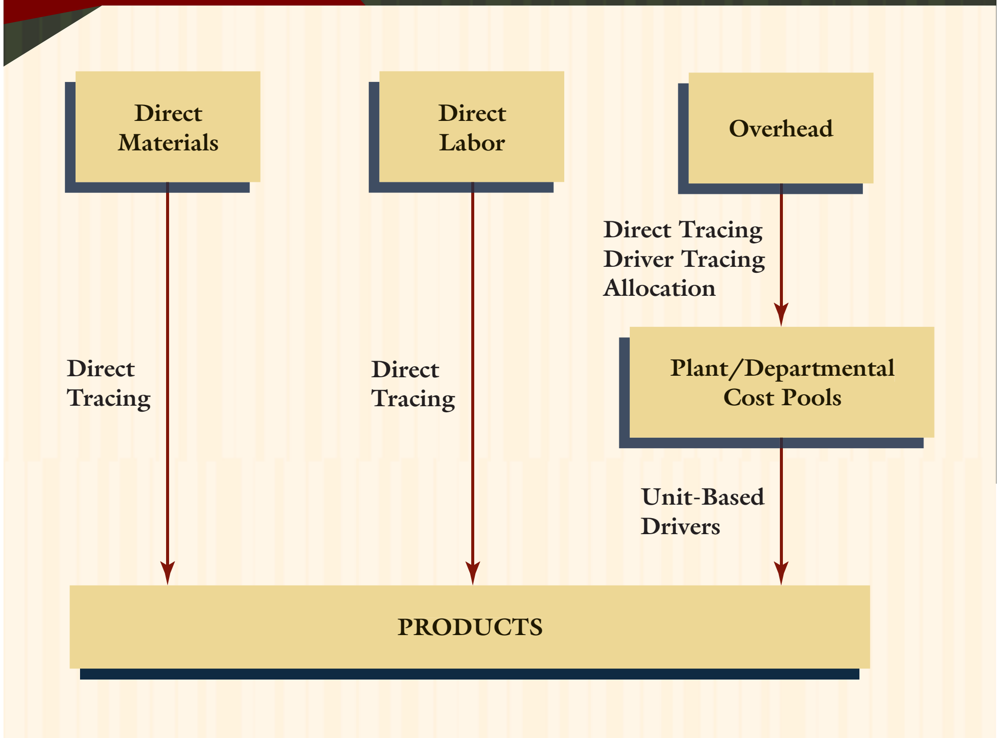
Unit-Level Product Costing

OBJECTIVE 1

Describe the basics of plantwide and departmental overhead costing.

Functional-based product costing assigns only manufacturing costs to products. Exhibit 4-1 shows the general functional-based product costing model. Assigning the cost of direct materials and direct labor to products poses no particular challenge. These costs can be assigned to products using direct tracing, and most functional-based costing systems are designed to ensure that this tracing takes place. Overhead costs, on the other hand, pose a different problem. The physically observable input-output relationship that exists between direct labor, direct materials, and products is simply not available for overhead. Thus, assignment of overhead must rely on driver tracing and perhaps allocation. Functional-based costing first assigns overhead costs to a functional unit, creating either plant or departmental cost pools. Next, these pooled costs are assigned to products using *predetermined overhead rates* based on unit-level drivers.

EXHIBIT 4-1 Functional-Based Product Costing Model



A **predetermined overhead rate** is calculated at the beginning of the year using the following formula:

Overhead rate = Budgeted annual overhead/Budgeted annual driver level

Predetermined rates are used because overhead and production often are incurred nonuniformly throughout the year, and it is not possible to wait until the end of the year to calculate the actual overhead cost assignments (managers need unit product cost information throughout the year). A cost system that uses predetermined overhead rates and actual costs for direct materials and direct labor is referred to as a **normal cost system**. Budgeted overhead is simply the firm's best estimate of the amount of overhead (utilities, indirect labor, depreciation, etc.) to be incurred in the coming year. The estimate is often based on last year's figures, adjusted for anticipated changes in the coming year. The second input requires that the predicted level for an activity driver be specified. Assignment of overhead costs should follow, as nearly as possible, a cause-and-effect relationship. Drivers are simply causal factors that measure the consumption of overhead by products. In functional-based costing, only *unit-level drivers* are used to calculate overhead rates.

Unit-level drivers are factors that measure the demands placed on unit-level activities by products. Unit-level activities are activities performed each and every time a unit of a product is produced. The five most commonly used unit-level drivers are:

1. Units produced
2. Direct labor hours
3. Direct labor dollars
4. Machine hours
5. Direct material dollars

Unit-level drivers increase as units produced increase. Thus, the use of only unit-based drivers to assign overhead costs to products assumes that all overhead consumed by products is highly correlated with the number of units produced. To the extent that this assumption is true, functional-based costing can produce accurate cost assignments.

Plantwide or departmental predetermined overhead rates are used to assign or apply overhead costs to production as the actual production activity unfolds. The total overhead assigned to actual production at any point in time is called **applied overhead**. Applied overhead is computed using the following formula:

$$\text{Applied overhead} = \text{Overhead rate} \times \text{Actual driver usage}$$

Overhead Assignment: Plantwide Rates

For plantwide rates, all budgeted overhead costs are assigned to a plantwide pool (first-stage cost assignment). Next, a plantwide rate is computed using a single unit-level driver, which is usually direct labor hours. Finally, overhead costs are assigned to products by multiplying the rate by the actual total direct labor hours used by each product (second-stage assignment).

These points are best illustrated with an example. Suncalc, Inc., produces two unique, solar-powered products: a pocket calculator and a currency translator used to convert foreign currency into dollars and vice versa. Suncalc uses a plantwide rate based on direct labor hours to assign its overhead costs. The company has the following estimated and actual data for the coming year:

Budgeted overhead		$360,000
Expected activity (in direct labor hours)		120,000
Actual activity (in direct labor hours):		
Pocket calculator	40,000	
Currency translator	60,000	
		100,000
Actual overhead		$320,000
Units produced:		
Pocket calculator		80,000
Currency translator		90,000

The overhead rate to be used is calculated as follows:

$$\begin{aligned}\text{Predetermined overhead rate} &= \text{Budgeted overhead/Normal activity}\\ &= \$360{,}000/120{,}000 \text{ direct labor hours}\\ &= \$3 \text{ per DLH}\end{aligned}$$

Using the overhead rate, applied overhead for the year is:

$$\begin{aligned}\text{Applied overhead} &= \text{Overhead rate} \times \text{Actual activity usage}\\ &= \$3 \text{ per DLH} \times 100{,}000 \text{ DLH}\\ &= \$300{,}000\end{aligned}$$

Per-Unit Overhead Cost

The predetermined overhead rate is the basis for per-unit overhead cost calculation:

	Pocket Calculator	*Currency Translator*
Units produced	80,000	90,000
Direct labor hours	40,000	60,000
Overhead applied to production ($3 × DLH)	$120,000	$180,000
Overhead per unit*	$1.50	$2.00

*Overapplied/Units produced.

Under- and Overapplied Overhead

Notice that the amount of overhead applied to production ($300,000) differs from the actual overhead ($320,000). Since the predetermined overhead rate is based on estimated data, applied overhead will rarely equal actual overhead. Since only $300,000 was applied in our example, the firm has underapplied overhead by $20,000. If applied overhead had been $330,000, too much overhead would have been applied to production. The firm would have overapplied overhead by $10,000. The difference between actual overhead and applied overhead is an **overhead variance**. If actual overhead is greater than applied overhead, then the variance is called **underapplied overhead**. If applied overhead is greater than actual overhead, then the variance is called **overapplied overhead**.

Overhead variances occur because it is impossible to perfectly estimate future overhead costs and production activity. Costs reported on the financial statements must be actual—not estimated—amounts. Accordingly, at the end of a reporting period, procedures must exist to dispose of any overhead variance.

Disposition of Overhead Variances

An overhead variance is disposed of in one of two ways:

1. If immaterial, it is assigned to cost of goods sold.
2. If material, it is allocated among work-in-process inventory, finished goods inventory, and cost of goods sold.

Assigned to Cost of Goods Sold

The most common practice is simply to assign the entire overhead variance to cost of goods sold. This practice is justified on the basis of materiality, the same principle used to justify expensing the entire cost of a pencil sharpener in the period acquired rather than allocating (through depreciation) its cost over the life of the sharpener. Thus, the overhead variance is added to cost of goods sold if underapplied and subtracted from cost of goods sold if overapplied. For example, assume that Suncalc has an ending balance in its cost of goods sold account equal to $500,000. The underapplied variance of $20,000 would be added to produce a new, adjusted balance of $520,000. Assuming that both actual and applied overhead are accumulated in the overhead control account, the journal entry associated with this adjustment would be:

Cost of Goods Sold	20,000	
Overhead Control		20,000

Allocation to Production Accounts

If the overhead variance is material, it should be allocated to the period's production. Conceptually, the overhead costs of a period belong to goods started but not completed (work-in-process inventory), goods finished but not sold (finished goods inventory), and goods finished and sold (cost of goods sold). The recommended way to achieve this allocation is to prorate the overhead variance based on the ending applied overhead balances in each account. Using applied overhead captures the original cause-and-effect relationships used to assign overhead. Using another balance, such as total manufacturing costs, may result in an unfair assignment of the additional overhead. For example, two products identical on all dimensions except for the cost of direct material inputs should receive the same overhead assignment. Yet, if total manufacturing costs were used to allocate an overhead variance, then the product with the more expensive direct materials would receive a higher overhead assignment.

To illustrate the disposition of the overhead variance using the recommended approach, assume that Suncalc's accounts had the following applied overhead balances at the end of the year:

Work-in-Process Inventory	$ 60,000
Finished Goods Inventory	90,000
Cost of Goods Sold	150,000
Total	$300,000

Given the preceding data, the percentage allocation of any overhead variance to the three accounts is:

Work-in-Process Inventory	20% ($60,000/$300,000)
Finished Goods Inventory	30% ($90,000/$300,000)
Cost of Goods Sold	50% ($150,000/$300,000)

Recall that Suncalc had a $20,000 underapplied overhead variance. Thus, Work-in-Process Inventory would receive 20 percent of $20,000 (or $4,000), Finished Goods Inventory would receive 30 percent of $20,000 (or $6,000), and Cost of Goods Sold would receive 50 percent of $20,000 (or $10,000). The associated journal entries for this adjustment would be:

Work-in-Process Inventory	4,000	
Finished Goods Inventory	6,000	
Cost of Goods Sold	10,000	
Overhead Control		20,000

Since underapplied means that too little overhead was assigned, these individual prorated amounts would be added to the ending account balances. Adding these amounts produces the following new adjusted balances of the three accounts:

	Unadjusted Balance	*Prorated Underapplied Overhead*	*Adjusted Balance*
Work-in-Process Inventory	$ 60,000	$ 4,000	$ 64,000
Finished Goods Inventory	90,000	6,000	96,000
Cost of Goods Sold	150,000	10,000	160,000

Of course, if too much overhead is assigned to production, the overapplied amount is subtracted from the account balances.

Overhead Application: Departmental Rates

For departmental rates, overhead costs are assigned to individual production departments, creating departmental overhead cost pools. In the first stage, producing departments are cost objects, and budgeted overhead costs are assigned using direct tracing, driver tracing, and allocation. Once costs are assigned to individual production departments, then unit-level drivers such as direct labor hours (for labor-intensive departments) and machine hours (for machine-intensive departments) are used to compute predetermined overhead rates for each department. Products passing through the departments are assumed to consume overhead resources in proportion to the departments' unit-based drivers (machine hours or direct labor hours used). Thus, in the second stage, overhead is assigned to products by multiplying the departmental rates by the amount of the driver used in the respective departments. The total overhead assigned to products is simply the sum of the amounts received in each department. Increased accuracy is the usual justification offered for the use of departmental rates.

The Suncalc example will again be used to illustrate departmental rates. Assume that Suncalc has two producing departments: fabrication and assembly. Machine hours are used to assign the overhead of fabrication, and direct labor hours are used to assign the overhead of assembly. The following data are provided:

	Fabrication	*Assembly*	*Total*
Overhead	$280,000	$80,000	$360,000
Direct labor hours:			
Pocket calculator	10,000	30,000	40,000
Currency translator	10,000	50,000	60,000
Total	20,000	80,000	100,000
Machine hours:			
Pocket calculator	5,000	1,000	6,000
Currency translator	15,000	2,000	17,000
Total	20,000	3,000	23,000

There is a predetermined rate calculated for each department:

Fabrication (based on machine hours): Rate = $280,000/20,000
= $14 per machine hour

Assembly (based on direct labor hours): Rate = $80,000/80,000
= $1 per direct labor hour

The per-unit overhead cost for each product can now be calculated:

	Pocket Calculator	*Currency Translator*
Units produced	80,000	90,000
Overhead applied to production:		
Fabrication:		
$14 × 5,000	$ 70,000	
$14 × 15,000		$210,000
Assembly:		
$1 × 30,000	30,000	
$1 × 50,000		50,000
Total	$100,000	$260,000
Overhead per unit*	$1.25	$2.89

*Overapplied/Units produced.

OBJECTIVE 2

Explain why plantwide and departmental overhead costing may not be accurate.

Limitations of Plantwide and Departmental Rates

Plantwide and departmental rates have been used for decades and continue to be used successfully by many organizations. In some settings, however, they do not work well and may actually cause severe product cost distortions. Of course, to cause a significant cost distortion, overhead costs must be a significant percentage of total manufacturing costs. For some manufacturers, overhead costs are a small percentage (e.g., 5 percent or less), and the system in which these costs are assigned is not a major issue. In this case, using a very simple, uncomplicated approach such as plantwide rates is appropriate. Assuming, however, that the overhead costs are a significant percentage of total manufacturing costs, at least two major factors can impair the ability of the unit-based plantwide and departmental rates to assign overhead costs accurately: (1) the proportion of non-unit-related overhead costs to total overhead costs is large, and (2) the degree of product diversity is great.

Non-Unit-Related Overhead Costs

The use of either plantwide rates or departmental rates assumes that a product's consumption of overhead resources is related strictly to the units produced. But what if there are overhead activities that are unrelated to the number of units produced? Setup costs, for example, are incurred each time a batch of products is produced. A batch may consist of 1,000 or 10,000 units, and the cost of setup is the same. Yet, as more setups are done, setup costs increase. The number of setups, not the number of units produced, is the cause of setup costs. Furthermore, product engineering costs may depend on the number of different engineering work orders rather than the units produced of any given product. Both these examples illustrate the existence of non-unit-based drivers. **Non-unit-based drivers** are factors, other than the number of units produced, that measure the demands that cost objects place on activities. Thus, unit-level drivers cannot assign these costs accurately to products. In fact, using only unit-level drivers to assign non-unit-related overhead costs can create distorted product costs. The severity of this distortion depends on what proportion of total overhead costs these non-unit-based costs represent. For many companies, this percentage can be significant—reaching more than 40 or 50 percent of the total. Clearly, as this percentage decreases, the acceptability of using unit-based drivers for assigning costs increases.

Product Diversity

Significant nonunit overhead costs will not cause product cost distortions provided products consume the nonunit overhead activities in the same proportion as the unit-level overhead activities. Product diversity, on the other hand, can cause product cost distortion. **Product diversity** simply means that products consume overhead activities in different proportions. Product diversity is caused by such things as differences in product size, product complexity, setup time, and size of batches. The proportion of each activity consumed by a product is defined as the **consumption ratio**. The way that nonunit overhead costs and product diversity can produce distorted product costs (when only unit-level drivers are used to assign overhead costs) is best illustrated with an example.

An Example Illustrating the Failure of Unit-Based Overhead Rates

To illustrate the failure of plantwide and departmental rates, consider Goodmark Company, a company with a plant that produces two products: scented and regular birthday cards. Scented cards emit a pleasant fragrance when opened. The two producing departments are cutting and printing. Cutting is responsible for shaping the cards, and printing is responsible for design and wording (including the insertion of the fragrance for the scented cards). Expected product costing data are given in Exhibit 4-2. The units are boxes of one dozen cards. Because the quantity of regular cards produced is 10 times greater than that of scented cards, we can label the regular cards a high-volume product and scented cards a low-volume product. The cards are produced in batches.

For ease of presentation, only four types of overhead activities, performed by four distinct support departments, are assumed: setting up the equipment for each batch, machining, inspecting, and moving a batch. Each box of 12 cards is inspected after each department's operations. After cutting, the cards are inspected individually to ensure correct shape. After printing, the boxes of cards are also inspected individually to ensure correct wording, absence of smudges, insertion of fragrance, etc. Overhead costs are assigned to the two production departments using the direct method (described in Chapter 7). Setup costs are assigned based on the number of setups handled by each department. Since the number is identical, each department receives 50 percent of the total setup costs. Machining costs are assigned in proportion to the number of machine hours used by each department. Finally, inspection costs are assigned in proportion to the number of inspection hours used. The costs of moving materials are assigned by the number of moves used by each department (which is the same for each department).

Plantwide Overhead Rate

The total overhead for the plant is \$720,000, the sum of the overhead for each department (\$216,000 + \$504,000). Assume that direct labor hours are used as the unit-based activity driver. Dividing the total overhead by the total direct labor hours yields the following overhead rate:

$$\begin{aligned}\text{Plantwide rate} &= \$720{,}000/180{,}000 \text{ direct labor hours}\\ &= \$4.00 \text{ per direct labor hour}\end{aligned}$$

Using this plantwide rate and other information from Exhibit 4-2, the unit costs for each product are calculated and shown in Exhibit 4-3. Prime costs are assigned using direct tracing.

Departmental Rates

Based on the distribution of labor hours and machine hours in Exhibit 4-2, the cutting department is labor intensive, and the printing department is machine intensive. Moreover, the overhead costs of the cutting department are almost 43 percent of those

EXHIBIT 4-2 Product Costing Data

	Scented Cards	Regular Cards	Total
Units produced per year	20,000	200,000	—
Prime costs	$160,000	$1,500,000	$1,660,000
Direct labor hours	20,000	160,000	180,000
Number of setups	60	40	100
Machine hours	10,000	80,000	90,000
Inspection hours	2,000	16,000	18,000
Number of moves	180	120	300

	Departmental Data		
	Cutting Dept.	Printing Dept.	Total
Direct labor hours:			
Scented cards	10,000	10,000	20,000
Regular cards	150,000	10,000	160,000
Total	160,000	20,000	180,000
Machine hours:			
Scented cards	2,000	8,000	10,000
Regular cards	8,000	72,000	80,000
Total	10,000	80,000	90,000
Overhead costs:			
Setting up equipment	$120,000	$120,000	$240,000
Moving materials	60,000	60,000	120,000
Machining	20,000	180,000	200,000
Inspecting products	16,000	144,000	160,000
Total	$216,000	$504,000	$720,000

EXHIBIT 4-3 Unit Cost Computation: Plantwide Rates

	Scented	Regular
Prime costs	$160,000	$1,500,000
Overhead costs:		
$4.00 × 20,000	80,000	
$4.00 × 160,000		640,000
Total manufacturing costs	$240,000	$2,140,000
Units of production	÷ 20,000	÷ 200,000
Unit cost	$ 12.00	$ 10.70

of the printing department. Based on these observations, it could be argued that departmental overhead rates would reflect the consumption of overhead better than would a plantwide rate. If true, product costs would be more accurate. This approach would yield the following departmental rates, using direct labor hours for the cutting department and machine hours for the printing department.

Cutting department rate = $216,000/160,000 direct labor hours
= $1.35 per direct labor hour

Printing department rate = $504,000/80,000 machine hours
= $6.30 per machine hour

Using these departmental rates and the data from Exhibit 4-2, the computations of the unit costs for each product are shown in Exhibit 4-4. (Prime costs are assigned using direct tracing.)

EXHIBIT 4-4 Unit Cost Computation: Departmental Rates

	Scented	Regular
Prime costs	$160,000	$1,500,000
Overhead costs:		
[($1.35 × 10,000) + ($6.30 × 8,000)]	63,900	
[($1.35 × 150,000) + ($6.30 × 72,000)]		656,100
Total manufacturing costs	$223,900	$2,156,100
Units of production	÷ 20,000	÷ 200,000
Unit cost	$ 11.20*	$ 10.78*

*Rounded to the nearest cent.

Problems with Costing Accuracy

The accuracy of the overhead cost assignment can be challenged regardless of whether plantwide or departmental rates are used. The main problem with either procedure is the assumption that machine hours or direct labor hours drive or cause all overhead costs.

From Exhibit 4-2, we know that regular cards, the high-volume product, use eight times the direct labor hours used by the scented cards, the low-volume product (160,000 hours versus 20,000 hours). Thus, if a plantwide rate is used, the regular cards will receive eight times more overhead cost than will the scented cards. But is this reasonable? Do unit-based activity drivers explain the consumption of all overhead activities? In particular, can we reasonably assume that each product's consumption of overhead increases in direct proportion to the direct labor hours used? Let's look at the four overhead activities and see if unit-based drivers accurately reflect the demands of the regular and scented cards for overhead resources.

Machining and inspection appear to be unit-level costs, since they represent resources consumed each time a unit (card) is produced (recall that inspection is 100 percent). Thus, using direct labor hours to assign these costs appears reasonable. However, the data in Exhibit 4-2 suggest that a significant portion of overhead costs is not driven or caused by the units produced (measured by direct labor hours). For example, each product's demands for the setup and material-moving activities are more logically related to the number of production runs and the number of moves, respectively. These nonunit activities represent 50 percent ($360,000/$720,000) of the total overhead costs—a significant percentage. Notice that the low-volume product, scented cards, uses one and one-half times as many runs as do the regular cards (60/40) and one and one-half as many moves (180/120). However, use of direct labor hours, a unit-based activity driver, and a plantwide rate assigns eight times more setup and materials handling costs to the regular cards than to the scented. Thus, we have product diversity, and we should expect product cost distortion because the quantity of unit-based overhead that each product consumes does not vary in direct proportion to the quantity consumed of non-unit-based overhead. The consumption ratios for the two products are illustrated in Exhibit 4-5. Consumption ratios are simply the proportion of each activity consumed by a product. The consumption ratios suggest that a plantwide rate based on direct labor hours will overcost the regular cards and undercost the scented cards.

EXHIBIT 4-5 Product Diversity: Consumption Ratios

	Consumption Ratios		
Overhead Activity	**Scented**	**Regular**	**Activity Driver**
Setups	0.60[a]	0.40[a]	Production runs
Moving materials	0.60[b]	0.40[b]	Number of moves
Machining	0.11[c]*	0.89[c]*	Machine hours
Inspection	0.11[d]*	0.89[d]*	Inspection hours

[a] 60/100 (scented) and 40/100 (regular).
[b] 180/300 (scented) and 120/300 (regular).
[c] 10,000/90,000 (scented) and 80,000/90,000 (regular).
[d] 2,000/18,000 (scented) and 16,000/18,000 (regular).
*Rounded.

The problem is only aggravated when departmental rates are used. In the cutting department, regular cards consume 15 times as many direct labor hours as do the scented cards (150,000/10,000). In the printing department, regular cards consume nine times as many machine hours as the scented cards (72,000/8,000). Thus, the regular cards receive about 15 times more overhead than do the scented cards in the cutting department, and in the printing department, they receive nine times more overhead. As Exhibit 4-4 shows, with departmental rates, the unit cost of the scented cards decreases by $0.80 to $11.20, and the unit cost of the regular cards increases by $0.08 to $10.78. This change is in the wrong direction, which emphasizes the failure of unit-based activity drivers to reflect accurately each product's demands for the setup and material-moving costs.

Activity Rates: A Possible Solution

The most direct method of overcoming the distortions caused by the unit-level rates is to expand the number of rates used so that the rates reflect the actual consumption of overhead costs by the various products. Thus, instead of pooling the overhead costs in plant or departmental pools, rates are calculated for each individual overhead activity. The rates are based on causal factors that measure consumption (unit- and non-unit-level activity drivers). Using this approach and the data from Exhibit 4-2, the following activity rates are computed for each activity:

Setting up equipment: \$240,000/100 setups = \$2,400 per setup
Machining: \$200,000/90,000 machine hours = \$2.22* per machine hour
Inspecting: \$160,000/18,000 inspection hours = \$8.89* per inspection hour
Moving materials: \$120,000/300 moves = \$400 per move

*Rounded.

Costs are assigned to each product by multiplying the activity rates by the amount consumed by each activity (as measured by the activity driver). The unit costs using activity rates are shown in Exhibit 4-6.

EXHIBIT 4-6 Unit Cost Computation: Activity Rates

	Scented	Regular
Prime costs	\$160,000	\$1,500,000
Overhead costs:		
Setting up:		
\$2,400 × 60	144,000	
\$2,400 × 40		96,000
Machining:		
\$2.22 × 10,000	22,200	
\$2.22 × 80,000		177,600
Inspecting:		
\$8.89 × 2,000	17,780	
\$8.89 × 16,000		142,240
Moving materials:		
\$400 × 180	72,000	
\$400 × 120		48,000
Total manufacturing costs	\$415,980	\$1,963,840
Units of production	÷ 20,000	÷ 200,000
Unit cost	\$ 20.80*	\$ 9.82*

*Rounded to the nearest cent.

Comparison of Different Product Costing Methods

In Exhibit 4-7, the unit costs from activity-based costing are compared with the unit costs produced by functional-based costing using either a plantwide or departmental rate. This comparison clearly illustrates the effects of using only unit-based activity drivers to assign overhead costs. The activity-based cost assignment duplicates the pattern of overhead consumption and is therefore the most accurate of the three costs shown in Exhibit 4-7. Functional-based costing undercosts the scented cards and overcosts the regular cards. In fact, the ABC assignment increases the cost of the scented cards by at least \$8.80 per box and decreases the cost of the regular cards by at least \$0.88. Thus, in the presence of significant nonunit overhead costs and product diversity, using only unit-based activity drivers can lead to one product subsidizing another (as the regular cards are subsidizing the scented cards). This subsidy could create the appearance that one group of products is highly profitable and can adversely impact the pricing and competitiveness of another group of products. In a highly competitive environment, the more accurate the cost information, the better the planning and decision making.

EXHIBIT 4-7 Comparison of Unit Costs

	Scented Cards	Regular Cards	Source
Activity-based cost	$20.80	$ 9.82	Exhibit 4-6
Functional-based cost:			
Plantwide rate.	12.00	10.70	Exhibit 4-3
Departmental rates	11.20	10.78	Exhibit 4-4

ABC Users

The Goodmark Company example also helps us understand when ABC may be useful for a firm. First, multiple products are needed. ABC offers no increase in product costing accuracy for a single-product setting. Second, there must be product diversity. If products consume non-unit-level activities in the same proportion as unit-level activities, then ABC assignments will be the same as functional-based assignments. Third, non-unit-level overhead must be a significant percentage of production cost. If it is not, then it hardly matters how it is assigned. Thus, firms that have plants with multiple products, high product diversity, and significant non-unit-level overhead are candidates for an ABC system.

One survey studied this concept.[1] Of those firms surveyed, 49 percent had adopted ABC. When compared with nonadopting firms, it was found that adopting firms reported a higher potential for distorted costs and a higher level of overhead when expressed as a percentage of total production costs. Adopting firms also reported a greater need or utility for accurate cost information for decision making.

OBJECTIVE 3

Provide a detailed description of activity-based product costing.

Activity-Based Costing System

The Goodmark Company example shows quite clearly that prime costs are assigned in the same way for functional- or activity-based costing. The example also demonstrates that the total amount of overhead costs is assigned under either approach. The amount assigned to each product, though, can differ significantly, depending on which method is used. The theoretical premise of activity-based costing is that it assigns costs according to the resource consumption pattern of products. If this is true, then activity-based costing should produce more accurate product costs if there is product diversity simply because unit-based drivers cannot capture the full consumption pattern of products. The Goodmark example suggests that we simply need to choose among a plantwide cost pool, departmental cost pools, or activity cost pools. While this is true, it is also true that we are talking about different levels of aggregation. In reality, if there is no product diversity and a plantwide cost pool is chosen, all we need is the cost of overhead resources taken from the general ledger accounts: depreciation, salaries, utilities, rent, etc. On the other hand, departmental cost pools require more detail and less aggregation because costs must be assigned to every producing department. Finally, activity-based costing requires the most detail and the least aggregation because each activity performed and its associated costs must be identified.

As Exhibit 4-8 illustrates, an **activity-based costing (ABC) system** first traces costs to activities and then to products and other cost objects. The underlying assumption is

1. Kip Krumwiede, "ABC: Why It's Tried and How It Succeeds," *Management Accounting* (April 1998): 32–38.

that activities consume resources, and products and other cost objects consume activities. In designing an ABC system, there are six essential steps, as listed in Exhibit 4-9.

EXHIBIT 4-8 Activity-Based Costing Model

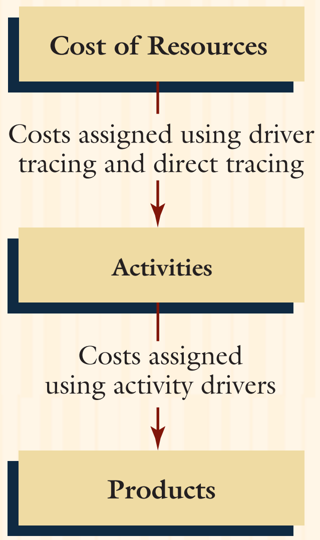


EXHIBIT 4-9 Design Steps for an ABC System

1. Identify, define, and classify activities and key attributes.
2. Assign the cost of resources to activities.
3. Assign the cost of *secondary* activities to *primary* activities.
4. Identify cost objects and specify the amount of each activity consumed by specific cost objects.
5. Calculate primary activity rates.
6. Assign activity costs to cost objects.

Activity Identification, Definition, and Classification

Identifying activities is a logical first step in designing an activity-based costing system. Activities represent actions taken or work performed by equipment or people for other people. Identifying an activity is equivalent to describing action taken—usually by using an action verb and an object that receives the action. A simple list of the activities identified is called an **activity inventory**. A sample activity inventory for an electronics manufacturer is listed in Exhibit 4-10. Of course, the actual inventory of activities for most organizations would list many more than 12 activities (200 to 300 are not uncommon).

Activity Definition

Once an inventory of activities exists, then activity attributes are used to define activities. **Activity attributes** are nonfinancial and financial information items that describe

EXHIBIT 4-10 Sample Activity Inventory

1. Developing test programs
2. Making probe cards
3. Testing products
4. Setting up lots
5. Collecting engineering data
6. Handling wafer lots
7. Inserting dies
8. Providing utilities
9. Providing space
10. Purchasing materials
11. Receiving materials
12. Paying for materials

individual activities. An **activity dictionary** lists the activities in an organization along with desired attributes. The attributes selected depend on the purpose being served. Examples of activity attributes with a product costing objective include tasks that describe the activity, types of resources consumed by the activity, amount (percentage) of time spent on an activity by workers, cost objects that consume the activity, and a measure of activity consumption (activity driver). Activities are the building blocks for both product costing and continuous improvement. An activity dictionary provides crucial information for activity-based costing as well as activity management. It is a key source of information for building an activity-based database that is discussed later in the chapter.

Activity Classification

Attributes define and describe activities and, at the same time, become the basis for activity classification. Activity classification facilitates the achievement of key managerial objectives such as product or customer costing, continuous improvement, total quality management, and environmental cost management. For example, for costing purposes, activities can be classified as primary or secondary. A **primary activity** is an activity that is consumed by a final cost object such as a product or customer. A **secondary activity** is one that is consumed by intermediate cost objects such as primary activities, materials, or other secondary activities. Recognizing the difference between the two types of activities facilitates product costing. Exhibit 4-8 indicates that activities consume resources. Thus, in the first stage of activity-based costing, the cost of resources is assigned to activities. Exhibit 4-8 also reveals that products consume activities—but only primary activities. Thus, before assigning the costs of primary activities to products, the costs of the secondary activities consumed by primary activities must be assigned to the primary activities. Many other useful activity classifications exist. For example, activities can be classified as *value-added* or *non-value-added* (defined and discussed in detail in Chapter 12), as *quality-related* (discussed in Chapter 14), or as *environmental* (discussed in Chapter 16). In designing an activity costing system, the desired attributes and essential classifications need to be characterized up front so that the necessary data can be collected for the activity dictionary.

Gathering the Necessary Data

Interviews, questionnaires, surveys, and observation are means of gathering data for an ABC system. Interviews with managers or other knowledgeable representatives of functional departments are perhaps the most common approach for gathering the needed information. Interview questions can be used to identify activities and activity attributes needed for costing or other managerial purposes. The information derived from interview questions serves as the basis for constructing an activity dictionary and provides data helpful for assigning resource costs to individual activities. In structuring an interview, the questions should reveal certain key attributes. Interview questions should be structured to provide answers that allow the desired attributes to be identified and measured. An example is perhaps the best way to show how an interview can be used to collect the data for an activity dictionary.

Illustrative Example

Suppose that a hospital is carrying out an ABC pilot study to determine the nursing cost for different types of cardiology patients. The cardiology unit is located on one floor of the hospital. The interview with the unit's nursing supervisor is provided below. Questions are given along with their intended purposes and the supervisor's responses. The interview is not intended to be viewed as an exhaustive analysis but rather represents a sample of what could occur.

Question 1 (Activity Identification): Can you describe what your nurses do for patients in the cardiology unit? (Activities are people doing things for other people.)

Response: There are four major activities: treating patients (administering medicine and changing dressings), monitoring patients (checking vital signs and posting patient information), providing hygienic and physical care for patients (bathing, changing bedding and clothes, walking the patient, etc.), and responding to patient requests (counseling, providing snacks, and answering calls).

Question 2 (Activity Identification): Do any patients use any equipment? (Activities also can be equipment doing work for other people.)

Response: Yes. In the cardiology unit, monitors are used extensively. Monitoring is an important activity for this type of patient.

Question 3 (Activity Identification): What role do you have in the cardiology unit? (Activities are people doing things for other people.)

Response: I have no direct contact with the patients. I am responsible for scheduling, evaluations, and resolving problems with the ward's nurses.

Question 4 (Resource Identification): What resources are used by your nursing care activities (equipment, materials, energy)? (Activities consume resources in addition to labor.)

Response: Uniforms (which are paid for by the hospital), computers, nursing supplies such as scissors and instruments (supplies traceable to a patient are charged to the patient), and monitoring equipment at the nursing station.

Question 5 (Resource Driver Identification): How much time do nurses spend on each activity? How much equipment time is spent on each activity? (Information is needed to assign the cost of labor and equipment to activities.)

Response: We recently completed a work survey. About 25 percent of a nurse's time is spent treating patients, 20 percent providing hygienic care, 40 percent responding to patient requests, and 15 percent on monitoring patients. My time is 100 percent supervision. The monitoring equipment is used 100 percent for monitoring activity. Use of the computer is divided between 40 percent for supervisory work and 60 percent for monitoring. (Posting readings to patient records is viewed as a monitoring task.)

Question 6 (Potential Activity Drivers): What are the outputs of each activity? That is, how would you measure the demands for each activity? (This question helps identify activity drivers.)

Response: Treating patients: number of treatments; providing hygienic care: hours of care; responding to patient requests: number of requests; and monitoring patients: monitoring hours.

Question 7 (Potential Cost Objects Identified): Who or what uses the activity output? (Identifies the cost object: products, other activities, customers, etc.)

Response: Well, for supervising, I schedule, evaluate performance, and try to ensure that the nurses carry out their activities efficiently. Nurses benefit from what I do. Patients receive the benefits of the nursing care activities. We have three types of cardiology patients: intensive care, intermediate care, and normal care. These patients make quite different demands on the nursing activities. For example, intensive care patients rarely have walking time but use a lot of treatments and need more monitoring time.

Activity Dictionary

Based on the answers to the interview, an activity dictionary can now be prepared. Exhibit 4-11 illustrates the dictionary for the cardiology unit. The activity dictionary names the activity (typically by using an action verb and an object that receives the action), describes the tasks that make up the activity, classifies the activity as primary or secondary, lists the users (cost objects), and identifies a measure of activity output (activity driver). For example, the supervising activity is consumed by the following primary activities: treating patients, providing hygienic care, responding to patient requests, and monitoring patients. The three products—intensive care patients, intermediate care patients, and normal care patients—in turn, consume the primary activities.

EXHIBIT 4-11 Activity Dictionary: Cardiology Unit

Activity Name	Activity Description	Activity Type	Cost Object(s)	Activity Driver
Supervising nurses	Scheduling, coordinating, and performance evaluation	Secondary	Activities within department	Percentage of time nurses spend on each activity
Treating patients	Administering medicine and changing dressings	Primary	Patient types	Number of treatments
Providing hygienic care	Bathing, changing bedding and clothes, walking patients	Primary	Patient types	Labor hours
Responding to patient requests	Answering calls, counseling, providing snacks, etc.	Primary	Patient types	Number of requests
Monitoring patients	Checking vital signs and posting patient information	Primary	Patient types	Monitoring hours

Assigning Costs to Activities

After identifying and describing activities, the next task is determining how much it costs to perform each activity. The cost of an activity is simply the cost of the resources consumed by each activity. Activities consume resources such as labor, materials, energy, and capital. The cost of these resources is found in the general ledger, but how much is spent on each activity is not revealed. Resource costs must be assigned to activities using direct and driver tracing. For labor resources, a *work distribution matrix* is often used. A work distribution matrix simply identifies the amount of labor consumed by each activity and is derived from the interview process (or a written survey). For example, the nursing supervisor of the cardiology unit disclosed the following information about labor usage by the individual activities (see Question 5):

Percentage of Time on Each Activity

Activity	*Supervisor*	*Nurses*
Supervising nurses	100%	0%
Treating patients	0	25
Providing hygienic care	0	20
Responding to requests	0	40
Monitoring patients	0	15

The time spent on each activity is the driver used to assign the labor costs to the activity. If the time spent is 100 percent, then labor is exclusive to the activity, and direct tracing is the cost assignment method (such as the labor cost of supervision). On the other hand, the nursing resource is shared by several activities, and driver tracing is used for the cost assignment. These drivers are called resource drivers. **Resource drivers** are factors that measure the consumption of resources by activities. To illustrate, assume the general ledger reveals that the supervisor's salary is \$50,000 and that the salaries of the nurses total \$300,000. The amount of nursing cost assigned to each activity is as follows:

Supervising nurses	\$50,000 (by direct tracing)
Treating patients	\$75,000 (0.25 × \$300,000)
Providing hygienic care	\$60,000 (0.20 × \$300,000)
Responding to requests	\$120,000 (0.40 × \$300,000)
Monitoring patients	\$45,000 (0.15 × \$300,000)

Interviews, survey forms, questionnaires, and timekeeping systems are examples of tools that can be used to collect data on resource drivers. Notice that tracking the effort spent on different activities is similar to tracking the time that laborers spend on different jobs. However, there is one critical difference. The percent of effort spent on various activities is usually fairly constant and may only need to be measured periodically (perhaps annually). The same constancy property also exists for other types of resource drivers. In effect, the labor time is a standard used to assign the cost of resources. Actual times need not be constantly measured and used to achieve the desired cost assignment.

Labor is only one of many resources consumed by activities. Activities also consume materials, capital, and energy. The interview, for example, reveals that cardiology care activities also include the use of monitors (capital), a computer (capital), uniforms (materials), and supplies (materials). The cost of these other resources is also assigned to activities using direct tracing and resource drivers. The cost of monitors, for example, is assigned using direct tracing. If the general ledger cost of the monitors were \$80,000, then this additional amount would be assigned directly to the monitoring activity. On the other hand, the cost of the computer is a resource shared by supervisory work (40 percent) and monitoring (60 percent) and is assigned using hours of usage, a time-based resource driver. Thus, if the cost of the computer were $1,200 per year, then an additional $480 would be assigned to the supervising activity and $720 to the monitoring activity. Up to this point, the cost of the monitoring activity is $125,720 ($45,000 + $80,000 + $720), and the cost of the supervising activity is $50,480 ($50,000 + $480). Repeating this process for all resources, the total cost of each activity can be calculated (e.g., assigning in the cost of uniforms and supplies, the monitoring activity is assumed to end up with a cost of $127,920 and supervising with a cost of $52,280—see Exhibit 4-12).

The assignment of resource costs to activities requires that the resource costs described in the general ledger be unbundled and reassigned. In a traditional accounting system, the general ledger reports costs by department and by spending account (based on a chart of accounts). The $300,000 of nursing salaries, for example, would be recorded as part of the total salaries of the cardiology unit. The general ledger indicates what is spent, but it does not reveal how the resources are spent. Of course, the resources are spent on the basic work (activities) performed in the department. In an activity-based cost system, costs must be reported by activity. Thus, an ABC system must restate the general ledger costs so that the new system reveals how the resources are being consumed. Exhibit 4-12 illustrates the unbundling concept for nursing care activities in the cardiology unit. As the exhibit indicates, the reassignment of resource costs to individual activities contributes to the creation of an ABC database for the organization.

EXHIBIT 4-12 Unbundling of General Ledger Costs

General Ledger ⟶ ABC Database

Cardiology Unit

Chart of Accounts View		ABC View	
Supervision	$ 50,000	Supervising nurses	$ 52,280
Supplies	40,600	Treating patients	90,000
Uniforms	8,200	Providing hygienic care	76,600
Salaries	300,000	Responding to requests	133,200
Computer	1,200	Monitoring patients	127,920
Monitor	80,000	Total	$480,000
Total	$480,000		

Assigning Secondary Activity Costs to Primary Activities

Assigning costs to activities completes the first stage of activity-based costing. In this first stage, activities are classified as primary and secondary. If there are secondary activities, then intermediate stages exist. In an intermediate stage, the cost of secondary activities is assigned to those activities (or other intermediate cost objects) that consume their output. For example, supervising nurses is a secondary activity. The output measure is the percentage of nursing time spent on each activity (see the sample activity dictionary in Exhibit 4-11). From the work distribution matrix prepared earlier, we know that the four primary activities use nursing resources in these proportions: 25

percent, 20 percent, 40 percent, and 15 percent. Assuming that supervising is consumed in proportion to the labor content of the four primary activities, the cost of supervising would be assigned using the four ratios just listed. The new costs using this secondary activity driver and the activity costs from Exhibit 4-12 are calculated and presented in Exhibit 4-13.

EXHIBIT 4-13 Assignment of Secondary Activity Costs to Primary Activities

Treating patients	$103,070[a]
Providing hygienic care	87,056[b]
Responding to requests	154,112[c]
Monitoring patients	135,762[d]

[a]$90,000 + (0.25 × $52,280).
[b]$76,600 + (0.20 × $52,280).
[c]$133,200 + (0.40 × $52,280).
[d]$127,920 + (0.15 × $52,280).

Cost Objects and Bills of Activities

Once the costs of primary activities are determined, these costs can then be assigned to products or other cost objects in proportion to their usage of the activity, as measured by activity drivers. However, before any assignment is made, the cost objects must be identified and the demands these objects place on the activities must be measured. Many different cost objects are possible: products, materials, customers, distribution channels, suppliers, and geographical regions are some examples. For our example, the cost objects are products (services): intensive cardiology care, intermediate cardiology care, and normal cardiology care. How to deal with cost assignment for other cost objects is discussed in a later section. **Activity drivers** measure the demands that cost objects place on activities. Most ABC system designs choose between one of two types of activity drivers: transaction drivers and duration drivers. **Transaction drivers** measure the number of times an activity is performed, such as the number of treatments and the number of requests. **Duration drivers** measure the demands in terms of the time it takes to perform an activity, such as hours of hygienic care and monitoring hours. Duration drivers should be used when the time required to perform an activity varies from transaction to transaction. If, for example, treatments for normal care patients average 10 minutes but for intensive care patients average 45 minutes, then treatment hours may be a much better measure of the demands placed on the activity of treating patients than the number of treatments.

With the drivers defined, a bill of activities can be created. A **bill of activities** specifies the product, expected product quantity, activities, and amount of each activity expected to be consumed by each product. Exhibit 4-14 presents a bill of activities for the cardiology care example.

Activity Rates and Product Costing

Primary activity rates are computed by dividing the budgeted activity costs by practical activity capacity, where activity capacity is the amount of activity output (as measured by the activity driver). Practical capacity is the activity output that can be produced if the activity is performed efficiently. Using data from Exhibits 4-13 and 4-14, the activity rates for the cardiology unit nursing care example can now be calculated:

EXHIBIT 4-14 Bill of Activities: Cardiology Unit

Activity	Activity Driver	Normal	Intermediate	Intensive	Total
Production (output)	Patient days	10,000	5,000	3,000	
Treating patients	Treatments	5,000	10,000	15,000	30,000
Providing hygienic care	Hygienic hours	5,000	2,500	8,500	16,000
Responding to requests	Requests	30,000	40,000	10,000	80,000
Monitoring patients	Monitoring hours	20,000	60,000	120,000	200,000

Rate Calculations:

Treating patients:	\$103,070/30,000 = \$3.44 per treatment
Providing hygienic care:	\$87,056/16,000 = \$5.44 per hour of care
Responding to requests:	\$154,112/80,000 = \$1.93 per request
Monitoring patients:	\$135,762/200,000 = \$0.68 per monitoring hour

Note: Rates are rounded to the nearest cent.

These rates provide the price charged for activity usage. Using these rates, costs are assigned as shown in Exhibit 4-15. As should be evident, the assignment process is the

EXHIBIT 4-15 Assigning Costs: Final Cost Objects

	Patient Type		
	Normal	Intermediate	Intensive
Treating patients:			
\$3.44 × 5,000	\$ 17,200		
\$3.44 × 10,000		\$ 34,400	
\$3.44 × 15,000			\$ 51,600
Providing hygienic care:			
\$5.44 × 5,000	27,200		
\$5.44 × 2,500		13,600	
\$5.44 × 8,500			46,240
Responding to requests:			
\$1.93 × 30,000	57,900		
\$1.93 × 40,000		77,200	
\$1.93 × 10,000			19,300
Monitoring patients:			
\$0.68 × 20,000	13,600		
\$0.68 × 60,000		40,800	
\$0.68 × 120,000			81,600
Total costs	\$115,900	\$166,000	\$198,740
Units	÷ 10,000	÷ 5,000	÷ 3,000
Nursing cost per patient day	\$ 11.59	\$ 33.20	\$ 66.25

same as that for the Goodmark example illustrated earlier in Exhibit 4-6 (see p. 132). However, we now know the details behind the development of the activity rates and usage measures. Furthermore, the hospital setting emphasizes the utility of activity-based costing in service organizations.

Classifying Activities

To help identify activity drivers and enhance the management of activities, activities are often classified into one of the following four general activity categories: (1) unit-level, (2) batch-level, (3) product-level, and (4) facility-level. **Unit-level activities** are those that are performed each time a unit is produced. Grinding, polishing, and assembly are examples of unit-level activities. **Batch-level activities** are those that are performed each time a batch is produced. The costs of batch-level activities vary with the number of batches but are fixed (and, therefore, independent) with respect to the number of units in each batch. Setups, inspections (if done by sampling units from a batch), purchasing, and materials handling are examples of batch-level activities. **Product-level activities** are those activities performed that enable the various products of a company to be produced. These activities and their costs tend to increase as the number of different products increases. Engineering changes (to products), developing product-testing procedures, introducing new products, and expediting goods are examples of product-level activities. **Facility-level activities** are those that sustain a factory's general manufacturing processes. Providing facilities, maintaining grounds, and providing plant security are examples.

Classifying activities into these general categories facilitates product costing because the costs of activities associated with the different levels respond to different types of activity drivers. (Cost behavior differs by level.) Knowing the activity level is important because it helps management identify the activity drivers that measure the amount of each activity output being consumed by individual products. Activity-based costing systems improve product costing accuracy by recognizing that many of the so-called fixed overhead costs vary in proportion to changes other than production volume. Level classification also provides insights concerning the root causes of activities and thus can help managers in their efforts to improve activity performance.

By understanding what causes these costs to increase or decrease, they can be traced to individual products. This cause-and-effect relationship allows managers to improve product costing accuracy, which can significantly improve decision making. Additionally, this large pool of fixed overhead costs is no longer so mysterious. Knowing the underlying behavior of many of these costs allows managers to exert more control over the activities that cause the costs. It also allows managers to identify which of the activities add value and which do not. Value analysis is the heart of activity-based management and is the basis for continuous improvement. Activity-based management and continuous improvement are explored in later chapters.

Reducing the Size and Complexity of an ABC System

OBJECTIVE 4

Explain how the number of activity rates can be reduced.

In principle, ABC requires an activity rate for each activity. An organization may have hundreds of different activities and, thus, hundreds of activity rates. Although information technology certainly is capable of handling this volume, there is merit to reducing the number of rates if it can be done without suffering a significant decrease in the accuracy of the cost assignments. After all, increased accuracy of cost assignments is the source of the decision benefits and the justification for using ABC. Fewer rates may produce more readable and manageable product cost reports, reducing the perceived complexity of an activity-based costing system and increasing its likelihood of managerial acceptance. For example, if there are a large number of activities on a bill of activities, managers are likely to find it too complex to read, interpret, and use. In this case, the more complex ABC system will not likely be sustained. One of the oft-cited reasons for refusing to implement an ABC system or for abandoning it, once implemented, is the perceived complexity of the system. Fewer rates may also reduce the ongoing cost of operating an ABC system. Predetermined rates require that actual activity data be collected so that overhead can be applied. Fewer rates thus reduce the ongoing data collection activity required. In practical terms, a complex ABC system may not be sustainable simply because there is too much actual driver data to collect effectively.

Approximately Relevant ABC Systems

It is possible that an organization is better off having an approximately relevant ABC system rather than a precisely useless one.[2] One intriguing suggestion for obtaining an approximately relevant ABC system is to do an analysis of the activity accounting system and to use only the most expensive activities for ABC assignment.[3] The costs of all other activities can be added to the cost pools of the expensive activities. For example, the costs of the less expensive activities could be allocated in proportion to the costs in each of the expensive activities. In this way, most costs are assigned to the products accurately. The costs of the most expensive activities are still assigned using appropriate cause-and-effect drivers, while the added costs are assigned somewhat arbitrarily. The advantages of this approach are that it is simple, easy to understand, and easy to implement. It also often provides a good approximation of the ABC costs.

To illustrate the approximately relevant ABC concept, consider the data for Sencillo Electronics presented in Exhibit 4-16 on page 144. Sencillo produces two types of wafers: Wafer A and Wafer B. A wafer is a thin slice of silicon used as a base for integrated circuits or other electronic components. The dies on each wafer represent a particular configuration—a configuration designed for use by a particular end product. Sencillo produces wafers in batches, where each batch corresponds to a particular type of wafer (A or B). In the wafer inserting and sorting process, dies are inserted, and the wafers are tested to ensure that the dies are not defective. From Exhibit 4-16, we see that the activity-based costs for Wafer A and Wafer B are \$800,000 and \$1,200,000, respectively. These activity-based costs are calculated using the 12 drivers. We also see that four activities (developing test programs, testing products, inserting dies, and purchasing materials) account for 75 percent of the total costs. The cost assignments using the cost pools and the associated drivers of these four activities are shown in Exhibit 4-17 on page 145. The costs of the inexpensive activities are allocated to the four expensive activities in proportion to their original cost.

Exhibit 4-17 illustrates that the ABC costs are approximated quite well by the reduced system of four drivers. For Wafer A, the error is about 2.5 percent [(\$820,000 − \$800,000)/\$800,000], using the larger 12-driver system in Exhibit 4-16 as the benchmark. If activity costs roughly follow the Pareto principle or 80/20 rule (80 percent of the overhead costs are caused by 20 percent of the activities), then this approach for reducing the size of the system has some promise. For example, if a system has 100 activities, then the top 20 activities (as measured by their cost) need to account for a very high percentage of the total costs. In those cases where this holds, a reduced system may work reasonably well because *most* of the costs are assigned using cause-and-effect relationships. Even so, there may be some who would balk at the notion of using 15–20 drivers. The approach also loses its usefulness for those companies where a small number of activities do not account for a large share of the overhead costs.

2. Tom Pryor, "Simplify Your ABC," *Cost Management Newsletter* (June 2004), Issue No. 152.
3. Ibid.

EXHIBIT 4-16 Data for Sencillo Electronics

Activity	Budgeted Activity Cost	Driver	Expected Consumption Ratios Quantity[a]	Wafer A	Wafer B
Inserting and sorting process					
1. Developing test programs	$ 400,000	Engineering hours	10,000	0.25	0.75
2. Making probe cards	58,750	Development hours	4,000	0.10	0.90
3. Testing products	300,000	Test hours	20,000	0.60	0.40
4. Setting up batches	40,000	Number of batches	100	0.55	0.45
5. Engineering design	80,000	Number of change orders	50	0.15	0.85
6. Handling wafer lots	90,000	Number of moves	200	0.45	0.55
7. Inserting dies	350,000	Number of dies	2,000,000	0.70	0.30
Procurement process:					
8. Purchasing materials	450,000	Number of purchase orders	2,500	0.20	0.80
9. Unloading materials	60,000	Number of receiving orders	3,000	0.35	0.65
10. Inspecting materials	75,000	Inspection hours	5,000	0.65	0.35
11. Moving materials	30,000	Distance moved	3,000	0.50	0.50
12. Paying suppliers	66,250	Number of invoices	3,500	0.30	0.70
Total activity cost	$2,000,000				
Unit-level (plantwide) cost assignment[b]				$1,400,000	$600,000
Activity cost assignment[c]				$800,000	$1,200,000

[a]Total amount of the activity expected to be used by both products.
[b]Calculated using *number of dies* as the single unit-level driver: Wafer A = 0.7 × $2,000,000; Wafer B = 0.3 × $2,000,000.
[c]Calculated using *each* activity cost and either the associated consumption ratios or activity rates. For example, the cost assigned to Wafer A using the consumption ratio for *developing test programs* is 0.25 × $400,000 = $100,000. Repeating this for each activity and summing yields a total of $800,000 assigned to Wafer A.

Equally Accurate Reduced ABC Systems

Another approach is to use expected consumption ratios to reduce the number of drivers.[4] Consider again the 12 activities of Exhibit 4-16. The product costs assigned to Wafer A and Wafer B were $800,000 and $1,200,000, respectively. Thus, Wafer A is expected to consume 40 percent ($800,000/$2,000,000) of the total cost being assigned, and Wafer B is expected to consume 60 percent ($1,200,000/$2,000,000) of the total costs being assigned. Thus, Wafer A has an *expected global consumption ratio* of 0.40, and Wafer B has an *expected global consumption ratio* of 0.60. The **expected global consumption ratio** is the proportion of the total activity costs consumed by a given product (cost object). The expected global consumption ratio pattern for Sencillo Electronics is (0.40, 0.60). Each activity also has a consumption ratio pattern. For example, the consumption ratio pattern for the activity, *testing products*, is (0.60, 0.40). For a 2-product example, the activity consumption ratio patterns are always described by an array of two components. For the Sencillo Electronics example, the first ratio in the array is the proportion of the activity consumed by Wafer A, and the second ratio is the proportion consumed by Wafer B. As the number of products increases, the number of consumption ratio components also increases. The dimension of the consump-

4. Don R. Hansen and Shannon Leikam, "Reducing Complexity While Preserving Accuracy in Product Cost Systems," *Working Paper* (July 2004).

EXHIBIT 4-17 A Reduced System with Approximate ABC Assignments

Activity	Budgeted Activity Cost[a]	Driver	Expected Consumption Ratios Quantity	Wafer A	Wafer B
1. Developing test programs	$ 533,333	Engineering hours	10,000	0.25	0.75
3. Testing products	400,000	Test hours	20,000	0.60	0.40
7. Inserting dies	466,667	Number of dies	2,000,000	0.70	0.30
8. Purchasing materials	600,000	Number of purchase orders	2,500	0.20	0.80
Total activity cost	$2,000,000				
Reduced system ABC assignment[b]				$820,000	$1,180,000

[a]Original activity cost plus share of the costs of the remaining "inexpensive" activities. The costs of the inexpensive activities are allocated in proportion to the original costs of the expensive activities (as shown in Exhibit 4-16). For example, the cost pool for purchasing materials is $450,000 + [($450,000/$1,500,000) × $500,000] = $600,000.
[b]Costs are assigned to each product using the consumption ratios of the drivers of the respective cost pools. For example, the cost assigned to Wafer A for purchasing materials is 0.25 × $600,000 = $150,000. Repeating this calculation for the other three activities and summing yields a total of $820,000 assigned to Wafer A.

tion ratio pattern array corresponds to the number of products. When the number of activities is more than the number of products, it is always possible to find a reduced system that *duplicates* the cost assignments of the larger system. To achieve this duplication, the number of drivers needed is *at most* equal to the number of products.

For example, with the 2-product, 12-activity example of Exhibit 4-16, a reduced system of two drivers can always be identified that will achieve the *same* cost assignment as the larger 12-driver system.[5] Thus, once a larger system has been identified, a smaller system with the same accuracy can be created. To illustrate, consider two activities from Exhibit 4-16, testing products and purchasing materials. The consumption ratio vectors for the two activities are (0.6, 0.4) and (0.2, 0.8), respectively. For each product, the global consumption ratio can be expressed as a weighted combination of the consumption ratios for the two activities:

$$0.60w_1 + 0.20w_2 = 0.40 \text{ (Wafer A)} \quad (1)$$
$$0.40w_1 + 0.80w_2 = 0.60 \text{ (Wafer B)} \quad (2)$$

This gives two equations in two unknowns, w_1 and w_2 (there would be three equations for a 3-product setting, four for a 4-product setting, etc.). The weights are associated with the consumption ratios for each activity and product. These weights are used as *allocation rates* to create a cost pool for each activity. Solving Equations 1 and 2 yields $w_1 = 1/2$ and $w_2 = 1/2$. Multiplying 1/2 by the total cost of $2,000,000 yields a cost pool of $1,000,000 for testing products and a similar calculation produces a cost pool of $1,000,000 for purchasing materials. Exhibit 4-18 summarizes this analysis. Notice that when the resulting weights are 1/2, this corresponds to the average of the two sets of consumption ratios: [(0.6, 0.4) + (0.2, 0.8)]/2 = (*1/2*) (0.6, 0.4) + (*1/2*) (0.2, 0.8) = (0.4, 0.6).

The steps that should be followed to achieve the desired simplification are: (1) Calculate the expected global consumption ratio (ABC product cost/total overhead cost); (2) Select the needed number of activities (equal to the number of products); (3) Form

5. Ibid.

EXHIBIT 4-18 Reduced, Equally Accurate ABC System

Activity	Budgeted Activity Cost[a]	Driver	Quantity	Wafer A	Wafer B
			Expected Consumption Ratios		
3. Testing products	$1,000,000	Test hours	20,000	0.60	0.40
8. Purchasing materials	1,000,000	Purchase orders	2,500	0.20	0.80
Total activity cost	$2,000,000				
Reduced system ABC assignment[b]				$800,000	$1,200,000

[a]1/2 × $2,000,000 for each product, where the allocation ratio to detemine the cost pool is obtained by solving Equations 1 and 2.
[b]Costs are assigned to each product using the consumption ratios of the drivers of the respective cost pools. For example, the cost assigned to Wafer A is (0.60 × $1,000,000) + (0.20 × $1,000,000) = $800,000. If activity rates are used, then the rates would be $1,000,000/20,000 = $50 per test hour and $1,000,000/2,500 = $400 per purchase order. Wafer A is expected to use 12,000 (0.60 × 20,000) test hours and 500 (0.20 × 2,500) purchase orders. Using the rates and the expected usage produces the same expected product cost of $800,000.

equations by multiplying the consumption ratios of each product by the allocation weights and set this equal to the product's consumption ratio; (4) Solve the simultaneous set of equations; and (5) Use the weights to form the cost pools that will duplicate the larger ABC system cost assignments.

Exhibit 4-18 shows that an equally accurate simplified system can be derived from the more complex ABC system. Instead of using 12 drivers, it is possible to use only two drivers and achieve the same cost assignment of the more complex system. This reduced system represents an *after-the-fact* simplification. The reduced system is derived from an *existing* complex ABC data set. Of course, the same is true for the approximately relevant reduced system that uses the Pareto principle to achieve the reduction. The value of after-the-fact simplification is based on two key justifications. First, the reduced system eliminates the perceived complexity of the system. For example, it is much easier for nonfinancial users to read, interpret, and use a 2-driver system compared to a 12-driver system. Second, the reduced ABC system needs to collect actual driver data only for the drivers being used to assign the costs to products. For example, in the case of Sencillo Electronics, only actual data for testing hours and number of purchase orders need to be collected so that overhead costs can be assigned (applied) to the two products. This is much less costly than collecting actual data for 12 drivers. Finally, it should also be pointed out that the two drivers in Exhibit 4-18 are only one of many 2-driver combinations that can be used to reduce the ABC system without sacrificing the assignment accuracy of the more complex system.

ABC System Concepts

OBJECTIVE 5
Describe activity-based system concepts including an ABC relational database and ABC software.

One thing that should be immediately evident is that ABC is a much more detailed system than the more traditional functional-based system. This is also true for simplified ABC systems because they are after-the-fact simplifications. Although some firms use before-the-fact simplifications, such as simply selecting 10–15 drivers, there is no guarantee that they are achieving more accurate cost assignments (than their prior functional-based system) because they do not know the detailed ABC, cause-and-effect relationships. The emergence of ABC as a viable alternative to existing cost management systems is largely due to significant advances in information technology. Computations that once required the use of cumbersome mainframe computers can now be carried out with efficient, flexible ABC software using network PCs or even laptop computers. Furthermore, integrated database systems, known as enterprise resource planning (ERP) systems, are being widely adopted with the potential promise of integrating the activity-based costing system with that of a firmwide operational control costing system. ABC software requires the development of an activity-based costing (ABC) database, and an ERP system may facilitate its development.

ABC Database

An **ABC database** is the collected data sets that are organized and interrelated for use by an organization's activity-based costing information system. A **data set** is a grouping of logically related data. Creating an ABC database requires three steps. First, we must define and model the entities (objects) that are involved in the operation of an activity-based costing system. **Entities** are objects about which data are produced and gathered. The two most fundamental entities are activities and products. Other entities such as customers and distribution channels can also be defined. Second, a conceptual view must be developed that portrays the entities and the logical relationships that exist among the entities. Most of the chapter has been devoted to developing a conceptual understanding of the logical relationships that exist among activities and products. Third, the attributes that should be associated with each entity must be identified. These attributes are determined by the objectives of the information system being supported and by the needs of the users. For example, the objective of building homogeneous cost pools requires the following activity attributes: process membership, activity-level membership, activity driver, and budgeted activity costs. To complete the first stage, pool rates must be calculated. An additional activity attribute is needed for this purpose: activity capacity (measured in terms of the activity driver associated with the activity's homogeneous pool). Recall that pool rates are computed by dividing the budgeted pool costs by activity capacity.

Once the attributes and the entities are defined and identified, then a model must be selected that reflects the data structure implied by the entities and attributes. There are numerous ways of representing data structure. We will illustrate only one: relational structure. A **relational structure** uses a table to represent the overall logical view within a database. The table is made up of rows and columns, where the entity defines the rows, and the attributes define the columns. The tables needed for a relational database are defined by the relationships that exist among the entities. Each table should satisfy the following three properties: (1) the rows are fixed in length (each row has the same number of attributes), (2) each row is unique, and (3) the attributes for each row are directly related to a single entity.

To illustrate a relational table, consider once again the Sencillo Electronics example. Exhibit 4-19, on the following page, presents Sencillo's activity relational table. Notice that each row of the table is the same length (has the same number of attributes). Also, each row is unique, since each row corresponds to a different activity. Each activity is identified by an activity number, which acts as the unique primary key. A **primary key** is the attribute that uniquely identifies each row of data in a table (often referred to as a record). The activity number is the number associated with each activity in the activity inventory. For this example, the activity name is unique and could also serve as the primary key. Finally, notice that all nonkey attributes are fully dependent upon the primary key.

Once a database has been created, then data can be retrieved as needed. For example, the relational table in Exhibit 4-19 provides all the information needed to calculate individual activity rates. For example, the rate for activity 1 (developing test programs) is $40 per engineering hour ($400,000/10,000). Similar computations can be made for each activity. With the computation of the activity rates, the first stage of activity-based costing is completed.

The second stage assigns the pooled activity costs to individual products. Assigning costs to products necessitates the specification of activity demands, as measured by the drivers associated with each pool. Thus, a second relational table is needed: a

EXHIBIT 4-19 Activity Relational Table Illustrated

Activity Relational Table: Sencillo Electronics

Activity	Activity Name	Process	Activity Driver	Capacity	Cost
1	Developing test programs	Sorting	Engineering hours	10,000	$400,000
2	Making probe cards	Sorting	Development hours	4,000	58,750
3	Testing products	Sorting	Test hours	20,000	300,000
4	Setting up batches	Sorting	No. of batches	100	40,000
5	Engineering design	Sorting	No. of change orders	50	80,000
6	Handling wafer lots	Sorting	No. of moves	200	90,000
7	Inserting dies	Sorting	No. of dies	2,000,000	350,000
8	Purchasing materials	Procurement	No. of purchase orders	2,500	450,000
9	Unloading materials	Procurement	No. of receiving orders	3,000	60,000
10	Inspecting materials	Procurement	Inspection hours	5,000	75,000
11	Moving materials	Procurement	Distance moved	3,000	30,000
12	Paying suppliers	Procurement	No. of invoices	3,500	66,250

product relational table. This table is centered on the "product" entity and must have attributes that identify how costs are to be assigned. A product number or name that uniquely identifies each product can be used as the primary key. The attributes for carrying out the second stage of activity-based costing are the product's demands for each pool's activity driver and the units produced of each. The product relational table for Sencillo Electronics is shown in Exhibit 4-20. The table is structured to facilitate the addition or deletion of drivers as circumstances change. The product relational table illustrates the use of concatenated keys. **Concatenated keys** are two or more keys that uniquely identify a record. (Notice that one key, such as product name, is not sufficient.)

For example, in the product relational table, a row is uniquely identified by product number and driver number (or by product name and driver name). The information in this second table is vital for the second stage of ABC: assigning costs to individual products. To illustrate, consider how the costs of activity 1 (developing test programs) are assigned to Wafer A. The rate is $40 per engineering hour. From the product relational table in Exhibit 4-20, Wafer A is expected to use 2,500 engineering hours. Thus, the amount of activity 1's costs assigned to Wafer A is $100,000 ($40 × 2,500). This type of calculation would be repeated for every activity until the total cost assigned to Wafer A is determined. The same process is applied to every product.

ABC and ERP Systems

Activity-based software typically uses a relational structure for data. ABC software is an integral part of any successful ABC model design. Poor model design and architecture can lead to project failure. Choosing the correct ABC software is absolutely essential. The chosen software should have features that correlate with the functional capabilities of a firm's ABC system design. For example, every ABC system design identifies activities, assigns the cost of resources to the activities, and then assigns the cost of activities to products, customers, and other important cost objects. Thus, ABC software should have at least three distinct modules: resources, activities, and cost objects. Modules are structures that allow data to be entered, manipulated, and viewed. How the data can be manipulated is critical and reveals the functional flexibility of different software packages.

EXHIBIT 4-20 **Product Relational Table Illustrated**

Product Relational Table: Sencillo Electronics

Product Number	Product Name	Activity Driver Number	Activity Driver Name	Activity Usage
1	Wafer A	1	Engineering hours	2,500
1	Wafer A	2	Development hours	400
1	Wafer A	3	Test hours	12,000
1	Wafer A	4	No. of batches	55
1	Wafer A	5	No. of change orders	8
1	Wafer A	6	No. of moves	90
1	Wafer A	7	No. of dies	1,400,000
1	Wafer A	8	No. of purchase orders	500
1	Wafer A	9	No. of receiving orders	1,050
1	Wafer A	10	Inspection hours	3,250
1	Wafer A	11	Distance moved	1,500
1	Wafer A	12	No. of invoices	1,050
2	Wafer B	1	Engineering hours	7,500
2	Wafer B	2	Development hours	3,600
2	Wafer B	3	Test hours	8,000
2	Wafer B	4	No. of batches	45
2	Wafer B	5	No. of change orders	33
2	Wafer B	6	No. of moves	110
2	Wafer B	7	No. of dies	600,000
2	Wafer B	8	No. of purchase orders	2,000
2	Wafer B	9	No. of receiving orders	1,950
2	Wafer B	10	Inspection hours	1,750
2	Wafer B	11	Distance moved	1,500
2	Wafer B	12	No. of invoices	2,450

To illustrate, consider an activity module. ABC software should allow costs to be assigned both within the activity module and between the activity module and the other modules. The ability to assign costs within the activity module allows a firm to distribute costs from secondary activities to primary activities. Transferring costs across modules allows costs to be assigned from primary activities (activity module) to products (cost object module). Thus, the cost assignment paths allowed by a software package are important features to consider. The more cost assignment paths allowed, the more flexible is the ABC system design allowed (by the particular software).

In addition to identifying functional requirements and matching these requirements with software capabilities, a manager should identify the information required by key users of an ABC system and then specify the output needed. The information needs define the output. For example, suppose that the environmental manager wants to know the environmental costs associated with the company's products and processes. In this case, the ABC system would need to identify all environmental activities and assign the costs of these activities to the products and processes. The output needed would then include environmental cost reports.

COST MANAGEMENT Technology in Action

Activity-based costing is useful for all types of organizations and businesses. For example, the Small Business Administration (SBA) uses Oros®, activity-based costing software, to determine the costs of its activities and cost objects. The SBA adopted an ABC system because it provides a more accurate revelation of the costs of programs and services. This enables the SBA to engage in improvements that produce a more efficient delivery of its programs and services. ABC is used to prepare the SBA's annual statement of net costs. It is also used to prepare other unit cost reports. To maintain the accuracy of the assignment of resources costs to the various activities, the SBA conducts a survey (at least annually) of its employees to assess the amount of time spent on activities. Thus, the SBA's ABC work distribution matrix is frequently updated to ensure accurate activity cost determination.

Source: Taken from the Web site, http://www.sba.gov/cfo/abc, accessed July 16, 2004.

Implementation of ABC systems and the selection of ABC software are being affected by the desire to also utilize enterprise resource planning (ERP) systems. ERP software has the objective of using real-time data to improve the efficiency of organizational units and processes. Therefore, ERP applications are primarily concerned with a company's operational control information system. ERP applications require the use of actual costs measured with a high degree of precision and focus on supporting the objective of continuous improvement. To support continuous improvement, timely, accurate, and detailed information is needed. ABC systems, on the other hand, focus on customer and product profitability and seek to identify opportunities for process improvement. ABC assigns costs using predetermined activity rates; thus, the costs assigned do not necessarily correspond to actual costs. ABC also provides cost information about the entire value chain: suppliers, products, and customers. It is much broader in scope than the organizational-unit perspective of ERP applications. Because the two systems have different purposes, scopes, and cost definitions, it may not be possible to fully integrate them. It is important to recognize that there are different systems for different purposes.

However, even though ABC and ERP systems have different purposes, the two systems need to be integrated so that they can exchange vital information. As Exhibit 4-21 illustrates, ERP systems are a major source of data for the ABC model. ERP systems simplify and improve the data collection requirements of an ABC system. In principle, ERP systems integrate all the information systems of an organization into one enterprise-wide system. Thus, an ERP system can provide data from such diverse sources as human resources, inventory, financial accounting, production, and sales; consequently, much of the input data needed by the ABC model, such as resource drivers, activity drivers, and resource costs, can be provided efficiently and economically. In effect, the ABC software that supports the ABC system is analytic application software and functions independently of an organization's core transactions while simultaneously being dependent on the data found within an ERP system.[6] ERP systems, for example, can provide data for transactional activity drivers such as the number of purchase orders processed in the purchasing department or the number of purchase orders processed from the receiving department.

Exhibit 4-21 also illustrates that the relationship between the two systems is not one way. ABC sends results back to the operational control system. For example, ABC provides accurate costs for products, customers, activities, and processes. ABC can also signal where attention should be directed for continuous improvement efforts by calculating the potential savings from eliminating unnecessary activities or improving the

6. This point is emphasized by R. Shaw, "ABC and ERP: Partners at Last?" *Management Accounting* (November 1998): 56–58.

EXHIBIT 4-21 The Relationship between ABC and ERP Systems

efficiency of processes. Moreover, ABC supplies key information to support tactical and strategic decisions. For instance, ABC could provide the costs of purchasing activities as input to a make-or-buy decision being examined by the operational control system. This complimentary relationship coupled with the independent value of ABC and ERP applications suggests an attractive partnership. Indeed, this appears to be the case as many ERP companies such as **SAP**, **Oracle**, **JD Edwards**, and **PeopleSoft** have acquired or developed ABC modules for their ERP products.[7] The market for analytic applications is expected to grow, and ABC is supposedly the analytic application that is expected to receive the most attention for the next several years.[8] The bottom line is that ERP systems are increasing the likelihood that ABC systems will be implemented and used by forward-thinking organizations.

7. Ibid., 56–58.
8. Ibid., 57.

SUMMARY

Overhead costs have increased in significance over time and, in many firms, represent a much higher percentage of product costs than does direct labor. At the same time, many overhead activities are unrelated to the units produced. Functional-based costing systems are unable to properly assign the costs of these non-unit-related overhead activities. These overhead activities are consumed by products in different proportions than are unit-based overhead activities. Because of this, assigning overhead using only unit-based drivers can distort product costs. This can be a serious matter if the non-unit-based overhead costs are a significant proportion of total overhead costs.

Overhead assignments should reflect the amount of overhead demanded (consumed) by each product. Activity-based costing recognizes that not all overhead varies with the number of units produced. By using both unit- and non-unit-based activity drivers, overhead can be more accurately traced to individual products. This tracing is achieved by implementing the following steps: (1) identify, define, and classify activities and key attributes; (2) assign the cost of resources to activities; (3) assign the cost of secondary activities to primary activities; (4) identify cost objects and specify the amount of each activity consumed by specific cost objects; (5) calculate primary activity rates; and (6) assign activity costs to cost objects.

Simplified ABC systems can be derived from complex ABC systems. These simplified systems facilitate the presentation and use of ABC information. They also reduce the cost of collecting actual driver data. Two approaches were discussed: the approximately relevant reduced ABC system and the equally accurate reduced ABC system. The first approach may be useful for those firms where a few activities account for most of the overhead costs. The second system is useful whenever the number of activities is greater than the number of products (which is usually the case).

Creating and maintaining an activity-based database facilitates implementing an ABC system. Relational databases offer a simple and straightforward way of collecting and organizing ABC data. At least two relational tables are needed: one for activities and one for products. Once the relational tables are created, data can be extracted so that individual product costs can be computed. ABC software should have features that allow flexible ABC system designs. ABC and ERP systems are two different systems with different purposes and can achieve partial integration by careful interfacing.

REVIEW PROBLEM AND SOLUTION

Functional versus Activity-Based Costing

Tyson Lamp Company is noted for its full line of quality lamps. The company operates one of its plants in Green Bay, Wisconsin. That plant produces two types of lamps: classical and modern. Jane Martinez, president of the company, recently decided to change from a unit-based, traditional costing system to an activity-based costing system. Before making the change companywide, she wanted to assess the effect on the product costs of the Green Bay plant. This plant was chosen because it produces only two types of lamps; most other plants produce at least a dozen.

To assess the effect of the change, the following data have been gathered (for simplicity, assume one process):

Lamp	*Quantity*	*Prime Costs*	*Machine Hours*	*Material Moves*	*Setups*
Classical	400,000	$800,000	81,250	300,000	100
Modern	100,000	$150,000	43,750	100,000	50
Dollar amount	—	$950,000	$500,000*	$900,000	$600,000

*The cost of operating the production equipment.

Under the current system, the costs of operating equipment, materials handling, and setups are assigned to the lamps on the basis of machine hours. Lamps are produced and moved in batches.

Required:

1. Compute the unit cost of each lamp using the current unit-based approach.
2. Compute the unit cost of each lamp using an activity-based costing approach.
3. Show how a reduced system using two cost pools and two drivers, moves and setups, can be used to achieve the same cost assignments obtained in Requirement 2.

SOLUTION

1. Total overhead is $2,000,000. The plantwide rate is $16 per machine hour ($2,000,000/125,000). Overhead is assigned as follows:

Classical lamps: $16 × 100,000 = $1,600,000
Modern lamps: $16 × 25,000 = $400,000

The unit costs for the two products are as follows:

Classical lamps: ($800,000 + $1,600,000)/400,000 = $6.00
Modern lamps: ($150,000 + $400,000)/100,000 = $5.50

2. In the activity-based approach, a rate is calculated for each activity:

Machining:	$500,000/125,000 = $4.00 per machine hour
Moving materials:	$900,000/400,000 = $2.25 per move
Setting up:	$600,000/150 = $4,000 per setup

Overhead is assigned as follows:

Classical lamps:	
$4.00 × 81,250	$ 325,000
$2.25 × 300,000	675,000
$4,000 × 100	400,000
Total	$1,400,000
Modern lamps:	
$4.00 × 43,750	$ 175,000
$2.25 × 100,000	225,000
$4,000 × 50	200,000
Total	$ 600,000

This produces the following unit costs:

Classical lamps:	
Prime costs	$ 800,000
Overhead costs	1,400,000
Total costs	$2,200,000
Units produced	÷ 400,000
Unit cost	$ 5.50
Modern lamps:	
Prime costs	$ 150,000
Overhead costs	600,000
Total costs	$ 750,000
Units produced	÷ 100,000
Unit cost	$ 7.50

3. First, calculate the activity consumption ratios:

	Moving	*Setups*
Classical	300,000/400,000 = 3/4	100/150 = 2/3
Modern	100,000/400,000 = 3/4	50/150 = 1/3

Second, calculate the global consumption ratios (information from Requirement 2 is needed):

	ABC Assignments	*Global Ratios*
Overhead assigned to classical	$1,400,000	$1,400,000/$2,000,000 = 0.70
Overhead assigned to modern	600,000	$600,000/$2,000,000 = 0.30
Total	$2,000,000	

Third, set up and solve the consumption ratio equations:

$$(3/4)w_1 + (2/3)w_2 = 0.70$$
$$(1/4)w_1 + (1/3)w_2 = 0.30$$

Solving, we have the allocation ratios: $w_1 = 0.40$ and $w_2 = 0.60$. Thus, the cost pools for the two activities are:

Moving: 0.40 × $2,000,000 = $800,000
Setups: 0.60 × $2,000,000 = $1,200,000

The activity rates for the reduced system would be:

Moving: $800,000/400,000 = $2.00 per move
Setups: $1,200,000/150 = $8,000 per setup

Overhead cost assignments:

Classical lamps:	
$2.00 × 300,000	$ 600,000
$8,000 × 100	800,000
Total	$1,400,000

Modern lamps:	
$2.00 × 100,000	$ 200,000
$8,000 × 50	400,000
Total	$ 600,000

KEY TERMS

QUESTIONS FOR WRITING AND DISCUSSION

1. What is a predetermined overhead rate? Explain why it is used.
2. Describe what is meant by under-and overapplied overhead.
3. Explain how a plantwide overhead rate, using a unit-based driver, can produce distorted product costs. In your answer, identify two major factors that impair the ability of plantwide rates to assign cost accurately.
4. What are non-unit-related overhead activities? Non-unit-based cost drivers? Give some examples.
5. What is an overhead consumption ratio?
6. Overhead costs are the source of product cost distortions. Do you agree or disagree? Explain.
7. What is activity-based product costing?
8. What are the six steps that define the design of an activity-based costing system?
9. Explain how the cost of resources is assigned to activities. What is meant by the phrase "unbundling the general ledger accounts"?
10. What is a bill of activities?
11. Identify and define two types of activity drivers.
12. What are unit-level activities? Batch-level activities? Product-level activities? Facility-level activities?
13. Describe two ways to reduce a complex ABC system. Of the two ways, which has the most merit?
14. How is an activity relational table constructed? A product relational table? In providing your answer, explain how attributes are selected.
15. Explain why ABC and ERP systems cannot be fully integrated. Now discuss how partial integration can be achieved.

EXERCISES

4-1 PREDETERMINED OVERHEAD RATE, APPLIED OVERHEAD, UNIT COST

LO1 Morrison, Inc., costs products using a normal costing system. The following data are available for last year:

Budgeted:	
Overhead	$952,000
Machine hours	140,000
Direct labor hours	34,000
Actual:	
Overhead	$950,000
Machine hours	137,000
Direct labor hours	33,100
Prime cost	$3,500,000
Number of units	500,000

Overhead is applied on the basis of direct labor hours.

Required:

1. What was the predetermined overhead rate?
2. What was the applied overhead for last year?
3. Was overhead over- or underapplied, and by how much?
4. What was the total cost per unit produced (carry your answer to four decimal places)?

4-2 Predetermined Overhead Rate, Application of Overhead

LO1 Bill Company and Ted Company both use predetermined overhead rates to apply manufacturing overhead to production. Bill's is based on machine hours, and Ted's is based on materials cost. Budgeted production and cost data for Bill and Ted are as follows:

	Bill	*Ted*
Manufacturing overhead	$304,000	$220,000
Units	10,000	20,000
Machine hours	16,000	7,500
Materials cost	$150,000	$400,000

At the end of the year, Bill Company had incurred overhead of $305,000 and had produced 9,800 units using 15,990 machine hours and materials costing $147,000. Ted Company had incurred overhead of $216,000 and had produced 20,500 units using 7,550 machine hours and materials costing $395,000.

Required:

1. Compute the predetermined overhead rates for Bill and Ted.
2. Was overhead over- or underapplied for each company, and by how much?

4-3 Predetermined Overhead Rate, Overhead Variances, Journal Entries

LO1 Menotti Company uses a predetermined overhead rate to assign overhead to jobs. Because Menotti's production is machine intensive, overhead is applied on the basis of machine hours. The expected overhead for the year was $3.8 million, and the practical level of activity is 250,000 machine hours.

During the year, Menotti used 255,000 machine hours and incurred actual overhead costs of $3.82 million. Menotti also had the following balances of applied overhead in its accounts:

Work-in-Process Inventory	$ 384,000
Finished Goods Inventory	416,000
Cost of Goods Sold	1,200,000

Required:

1. Compute a predetermined overhead rate for Menotti.
2. Compute the overhead variance, and label it as under- or overapplied.
3. Assuming the overhead variance is immaterial, prepare the journal entry to dispose of the variance at the end of the year.
4. Assuming the overhead variance is material, prepare the journal entry that appropriately disposes of the overhead variance at the end of the year.

4-4 DEPARTMENTAL OVERHEAD RATES

LO1 Mondragon Company produces machine tools and currently uses a plantwide overhead rate, based on machine hours. Alfred Cimino, the plant manager, has heard that departmental overhead rates can offer significantly better cost assignments than can a plantwide rate. Mondragon has the following data for its two departments for the coming year:

	Department A	*Department B*
Overhead costs (expected)	$60,000	$15,000
Normal activity (machine hours)	10,000	5,000

Required:

1. Compute a predetermined overhead rate for the plant as a whole based on machine hours.
2. Compute predetermined overhead rates for each department using machine hours.
3. Suppose that a machine tool (Product 12X75) used 20 machine hours from department A and 50 machine hours from department B. A second machine tool (Product 32Y15) used 50 machine hours from department A and 20 machine hours from department B. Compute the overhead cost assigned to each product using the plantwide rate computed in Requirement 1. Repeat the computation using the departmental rates found in Requirement 2. Which of the two approaches gives the fairest assignment? Why?
4. Repeat Requirement 3 assuming the expected overhead cost for department B is $30,000. Now would you recommend departmental rates over a plantwide rate?

4-5 DRIVERS AND PRODUCT COSTING ACCURACY

LO2, LO3 Larsen Company produces two types of leather purses: standard and handcrafted. Both purses use equipment for cutting and stitching. The equipment also has the capability of creating standard designs. The standard purses use only these standard designs. They are all of the same size to accommodate the design features of the equipment. The handcrafted purses can be cut to any size because the designs are created manually. Many of the manually produced designs are in response to specific requests of retailers. The equipment must be specially configured to accommodate the production of a batch of purses that will receive a handcrafted design. Larsen Company assigns overhead using direct labor dollars. Merle Jones, sales manager, is convinced that the purses are not being costed correctly.

To illustrate his point, he decided to focus on the expected annual setup and machine-related costs, which are as follows:

Setup equipment	$18,000
Depreciation	20,000*
Operating costs	22,000

*Computed on a straight-line basis, book value at the beginning of the year was $100,000.

The machine has the capability of supplying 100,000 machine hours over its remaining life.

Merle also collected the expected annual prime costs for each purse, the machine hours, and the expected production (which is the normal output for the company).

	Standard Purse	*Handcrafted Purse*
Direct labor	$12,000	$36,000
Direct materials	$12,000	$12,000
Units	3,000	3,000
Machine hours	18,000	2,000
Number of setups	40	40
Setup time	400 hrs.	200 hrs.

Required:

1. Do you think that the direct labor costs and direct materials costs are accurately traced to each type of purse? Explain.
2. The controller has suggested that overhead costs be assigned to each product using a plantwide rate based on direct labor dollars. Machine costs and setup costs are overhead costs. Assume that these are the only overhead costs. For each type of purse, calculate the overhead per unit that would be assigned using a direct labor dollars overhead rate. Do you think that these costs are traced accurately to each purse? Explain.
3. Now calculate the overhead cost per unit per purse using two overhead rates: one for the setup activity and one for the machining activity. In choosing a driver to assign the setup costs, did you use number of setups or setup hours? Why? As part of your explanation, define transaction and duration drivers. Do you think machine costs are traced accurately to each type of purse? Explain.

4-6 Multiple versus Single Overhead Rates, Activity Drivers

LO3, LO4

Plata Company has identified the following overhead activities, costs, and activity drivers for the coming year:

Activity	*Expected Cost*	*Activity Driver*	*Activity Capacity*
Setting up equipment	$120,000	Number of setups	300
Ordering costs	90,000	Number of orders	9,000
Machine costs	210,000	Machine hours	21,000
Receiving	100,000	Receiving hours	5,000

Plata produces two models of dishwashers with the following expected prime costs and activity demands:

	Model A	*Model B*
Direct materials	$150,000	$200,000
Direct labor	$120,000	$120,000
Units completed	8,000	4,000
Direct labor hours	3,000	1,000
Number of setups	200	100
Number of orders	3,000	6,000
Machine hours	12,000	9,000
Receiving hours	1,500	3,500

The company's normal activity is 4,000 direct labor hours.

Required:

1. Determine the unit cost for each model using direct labor hours to apply overhead.
2. Determine the unit cost for each model using the four activity drivers.
3. Which method produces the more accurate cost assignment? Why?

4-7 Activity-Based Costing; Activity Identification, Activity Dictionary

LO3 Golding Bank is in the process of implementing an activity-based costing system. A copy of an interview with the manager of Golding's credit card department follows:.

Question 1: How many employees are in your department?

Response: There are eight employees, including me.

Question 2: What do they do (please describe)?

Response: There are four major activities: supervising employees, processing credit card transactions, issuing customer statements, and answering customer questions.

Question 3: Do customers outside your department use any equipment?

Response: Yes. Automatic bank tellers service customers who require cash advances.

Question 4: What resources are used by each activity (equipment, materials, energy)?

Response: We each have our own computer, printer, and desk. Paper and other supplies are needed to operate the printers. Of course, we each have a telephone as well.

Question 5: What are the outputs of each activity?

Response: Well, for supervising, I manage employees' needs and try to ensure that they carry out their activities efficiently. Processing transactions produces a posting for each transaction in our computer system and serves as a source for preparing the monthly statements. The number of monthly customer statements has to be the product for the issuing activity, and I suppose that the number of customers served is the output for the answering activity. And I guess that the number of cash advances would measure the product of the automatic teller activity, although the teller really generates more transactions for other products such as checking and savings accounts. So, perhaps the number of teller transactions is the real output.

Question 6: Who or what uses the activity output?

Response: We have three products: classic, gold, and platinum credit cards. Transactions are processed for these three types of cards, and statements are sent to clients holding these cards. Similarly, answers to questions are all directed to clients who hold these cards. As far as supervising, I spend time ensuring the proper coordination and execution of all activities except for the automatic teller. I really have no role in managing that particular activity.

Question 7: How much time do workers spend on each activity? By equipment?

Response: I just completed a work survey and have the percentage of time calculated for each worker. All seven clerks work on each of the three departmental activities. About 40 percent of their time is spent processing transactions, with the rest of their time split evenly between issuing statements and answering questions. Phone time for all seven workers is used only for answering client questions. Computer time is 70 percent transaction processing, 20 percent statement preparation, and 10 percent question answering. Furthermore, my own time and that of my computer and telephone are 100 percent administrative. Credit card transactions represent about 20 percent of the total automatic teller transactions.

Required:

Prepare an activity dictionary using five columns: activity name, activity description, activity type (primary or secondary), cost object(s), and activity driver.

4-8 Assigning Resource Costs to Activities, Resource Drivers, Primary and Secondary Activities

LO3 Refer to the interview in **Exercise 4-7** (especially to Questions 4 and 7). The general ledger reveals the following annual costs:

Supervisor's salary	$ 64,600
Clerical salaries	210,000
Computers, desks, and printers	32,000
Computer supplies	7,200
Telephone expenses	4,000
ATM	1,250,000

All nonlabor resources, other than the ATM, are spread evenly among the eight credit department employees (in terms of assignment and usage). Credit department employees have no contact with ATMs. Printers and desks are used in the same ratio as computers by the various activities.

Required:

1. Determine the cost of all primary and secondary activities.
2. Assign the cost of secondary activities to the primary activities.

4-9 Assigning Resource Costs to Activities, Resource Drivers, Primary and Secondary Activities

LO3 Bob Randall, cost accounting manager for Hemple Products, was asked to determine the costs of the activities performed within the company's manufacturing engineering department. The department has the following activities: creating bills of materials (BOMs), studying manufacturing capabilities, improving manufacturing processes, training employees, and designing tools. The general ledger accounts reveal the following expenditures for manufacturing engineering:

Salaries	$500,000
Equipment	100,000
Supplies	30,000
Total	$630,000

The equipment is used for two activities: improving processes and designing tools. The equipment's time is divided by two activities: 40 percent for improving processes and 60 percent for designing tools. The salaries are for nine engineers, one who earns $100,000 and eight who earn $50,000 each. The $100,000 engineer spends 40 percent of her time training employees in new processes and 60 percent of her time on improving processes. One engineer spends 100 percent of her time on designing tools, and another engineer spends 100 percent of his time on improving processes. The remaining six engineers spend equal time on all activities. Supplies are consumed in the following proportions:

Creating BOMs	10%
Studying capabilities	5
Improving processes	35
Training employees	20
Designing tools	30

After determining the costs of the engineering activities, Bob was then asked to describe how these costs would be assigned to jobs produced within the factory. (The company manufactures machine parts on a job-order basis.) Bob responded by indicating that creating BOMs and designing tools were the only primary activities. The remaining were secondary activities. After some analysis, Bob concluded that studying manufacturing capabilities was an activity that enabled the other four activities to be realized. He also noted that all of the employees being trained are manufacturing workers—employees who work directly on the products. The major manufacturing activities are cutting, drilling, lathing, welding, and assembly. The costs of these activities are assigned to the various products using hours of usage (grinding hours, drilling hours, etc.). Furthermore, tools were designed to enable the production of specific jobs. Finally, the process improvement activity focused only on the five major manufacturing activities.

Required:

1. What is meant by unbundling general ledger costs? Why is it necessary?
2. What is the difference between a general ledger database system and an activity-based database system?
3. Using the resource drivers and direct tracing, calculate the costs of each manufacturing engineering activity. What are the resource drivers?
4. Describe in detail how the costs of the engineering activities would be assigned to jobs using activity-based costing. Include a description of the activity drivers that might be used. Where appropriate, identify both a possible transaction driver and a possible duration driver.

4-10 PROCESS IDENTIFICATION AND ACTIVITY CLASSIFICATION

LO3 Calzado Company produces leather shoes in batches. The shoes are produced in one plant located on 20 acres. The plant operates two shifts, five days per week. Each time a batch is produced, just-in-time suppliers deliver materials to the plant. When the materials arrive, a worker checks the quantity and type of materials with the bill of materials for the batch. The worker then makes an entry at a PC terminal near the point of delivery acknowledging receipt of the material. An accounts payable clerk reviews all deliveries at the end of each day and then prints and mails checks the same day materials are received. Prior to producing a batch, the equipment must be configured to reflect style and size features. Once configured, the batch is produced passing through three operations: cutting, sewing, and attaching buckles and other related parts such as heels. At the end of the production process, a sample of shoes is inspected to ensure the right level of quality.

After inspection, the batch is divided into lots based on the customer orders for the shoes. The lots are packaged in boxes and then transferred to a staging area to await shipment. After a short wait (usually within two hours), the lots are loaded onto trucks and delivered to customers (retailers).

Within the same plant, the company also has a team of design engineers who respond to customer feedback on style and comfort issues. This department modifies existing designs, develops new shoe designs, builds prototypes, and test markets the prototypes before releasing the designs for full-scale production.

Required:

1. Identify Calzado's processes and their associated activities.
2. Classify each activity within each process as unit-level, batch-level, product-level, or facility-level.

4-11 Approximately Relevant ABC

LO4 Golder Company has identified the following overhead activities, costs, and activity drivers for the coming year:

Spreadsheet

Activity	*Expected Cost*	*Activity Driver*	*Activity Capacity*
Setting up equipment	$252,000	Number of setups	300
Ordering materials	36,000	Number of orders	1,800
Machining	252,000	Machine hours	21,000
Receiving	60,000	Receiving hours	2,500

Golder produces two models of cell phones with the following expected activity demands:

	Model A	*Model B*
Units completed	10,000	20,000
Number of setups	200	100
Number of orders	600	1,200
Machine hours	12,000	9,000
Receiving hours	750	1,750

Required:

1. Determine the total overhead assigned to each product using the four activity drivers.
2. Determine the total overhead assigned to each model using the two most expensive activities. The costs of the two relatively inexpensive activities are allocated to the two expensive activities in proportion to their costs.
3. Using ABC as the benchmark, calculate the percentage error and comment on the accuracy of the reduced system. Explain why this approach may be desirable.

4-12 Equally Accurate Reduced ABC System

LO4 Refer to **Exercise 4-11**.

Required:

1. Calculate the global consumption ratios for the two products.
2. Using the activity consumption ratios for number of orders and number of setups, show that the same cost assignment can be achieved using these two drivers as that of the complete, 4-driver ABC system.

4-13 Activity Relational Table

LO5 Riobamba Manufacturing produces specially machined parts. The parts are produced in batches in one continuous manufacturing process. Each part is custom produced and requires special engineering design activity (based on customer specifications). Once the design is completed, the equipment can be set up for batch production. Once the batch is completed, a sample is taken and inspected to see if the parts are within the tolerances allowed. Thus, the manufacturing process has four activities: engineering, setups, machining, and inspecting. In addition, there is a sustaining process with two activities: providing utilities (plantwide) and providing space. Costs have been assigned to each activity using direct tracing and resource drivers as follows:

Engineering	$100,000
Setups	90,000
Machining	200,000
Inspecting	80,000
Providing space	25,000
Providing utilities	18,000

Activity drivers for each activity have been identified and their expected usage listed as follows:

Machine Hours	*Number of Setups*	*Engineering Hours*	*Inspection Hours*
20,000	150	4,000	2,000

The costs of facility-level activities are assigned using machine hours.

Required:

1. Identify the activities within each process as unit-level, batch-level, product-level, or facility-level.
2. Create an activity relational table that can be used to calculate activity rates.
3. Using the information in the activity relational table, calculate activity rates.

4-14 Product Relational Table, ABC

LO5

Spreadsheet

Maxwell Company recently installed an activity-based relational database. Using the information contained in the activity relational table, the following activity rates have been computed:

$200 per purchase order
$12 per machine hour, Process R
$15 per machine hour, Process D
$40 per engineering hour
$2 per packing order
$100 per square foot

Two products are produced by Maxwell: a deluxe disk player and a regular disk player. Each product has an area in the plant that is dedicated to its production. The plant has two manufacturing processes: the regular process (Process R) and the deluxe process (Process D). Other processes include engineering, product handling, and procurement. The product relational table for Maxwell is shown at the top of the following page.

Required:

1. Identify two different concatenated keys. What is the purpose of concatenated keys?
2. Using the activity rates and the information from the product relational table, calculate the unit overhead cost for each product.

Product Name	*Activity Driver Number*	*Activity Driver Name*	*Activity Usage*
Regular	1	Units	800,000
Regular	2	Purchase orders	1,000
Regular	3	Machine hours	320,000
Regular	4	Engineering hours	5,000
Regular	5	Packing orders	400,000
Regular	6	Square footage	6,000
Deluxe	1	Units	100,000
Deluxe	2	Purchase orders	500
Deluxe	3	Machine hours	40,000
Deluxe	4	Engineering hours	6,000
Deluxe	5	Packing orders	100,000
Deluxe	6	Square footage	4,000

PROBLEMS

4-15 Predetermined Overhead Rates, Overhead Variances, Unit Costs

LO1 Maricopa Company produces two products and uses a predetermined overhead rate to apply overhead. Maricopa currently applies overhead using a plantwide rate based on direct labor hours. Consideration is being given to the use of departmental overhead rates where overhead would be applied on the basis of direct labor hours in department 1 and on the basis of machine hours in department 2. At the beginning of the year, the following estimates are provided:

	Department 1	*Department 2*
Direct labor hours	200,000	40,000
Machine hours	20,000	60,000
Overhead cost	$120,000	$360,000

Actual results reported by department and product during the year are as follows:

	Department 1	*Department 2*
Direct labor hours	196,000	42,000
Machine hours	22,000	64,000
Overhead cost	$125,000	$385,000

	Product 1	*Product 2*
Direct labor hours:		
Department 1	150,000	46,000
Department 2	30,000	12,000
Machine hours:		
Department 1	13,000	10,000
Department 2	13,000	50,000

Required:

1. Compute the plantwide predetermined overhead rate, and calculate the overhead assigned to each product.
2. Calculate the predetermined departmental overhead rates, and calculate the overhead assigned to each product.
3. Using departmental rates, compute the applied overhead for the year. What is the under- or overapplied overhead for the firm?
4. Prepare the journal entry that disposes of the overhead variance calculated in Requirement 3, assuming it is not material in amount. What additional information would you need if the variance is material to make the appropriate journal entry?

4-16 Functional-Based versus Activity-Based Costing

LO2

Spreadsheet

Bienstar Company produces treadmills. One of its plants produces two versions: a standard model and a deluxe model. The deluxe model has a wider and sturdier base and a variety of electronic gadgets to help the exerciser monitor heartbeat, calories burned, distance traveled, etc. At the beginning of the year, the following data were prepared for this plant:

	Standard Model	*Deluxe Model*
Expected quantity	20,000	10,000
Selling price	$280	$575
Prime costs	$3 million	$3.5 million
Machine hours	25,000	25,000
Direct labor hours	50,000	50,000
Engineering support (hours)	9,000	21,000
Receiving (orders processed)	2,000	3,000
Materials handling (number of moves)	10,000	30,000
Purchasing (number of requisitions)	500	1,000
Maintenance (hours used)	4,000	16,000
Paying suppliers (invoices processed)	2,500	2,500
Setting up batches (number of setups)	40	360

Additionally, the following overhead activity costs are reported:

Maintenance	$ 400,000
Engineering support	600,000
Materials handling	800,000
Setups	500,000
Purchasing	300,000
Receiving	200,000
Paying suppliers	200,000
	$3,000,000

Required:

1. Calculate the cost per unit for each product using direct labor hours to assign all overhead costs.
2. Calculate activity rates and determine the overhead cost per unit. Compare these costs with those calculated using the functional-based method. Which cost is the most accurate? Explain.

4-17 ABC, Resource Drivers, Service Industry

LO2, LO3

Cushing Medical Clinic operates a cardiology care unit and a maternity care unit. Ned Carson, the clinic's administrator, is investigating the charges assigned to cardiology patients. Currently, all cardiology patients are charged the same rate per patient day for daily care services. Daily care services are broadly defined as occupancy, feeding, and nursing care. A recent study, however, revealed several interesting outcomes. First, the demands patients place on daily care services vary with the severity of the case being treated. Second, the occupancy activity is a combination of two activities: lodging and use of monitoring equipment. Since some patients require more monitoring than others, these activities should be separated. Third, the daily rate should reflect the difference in demands resulting from differences in patient type. Separating the occupancy activity into two separate activities also required the determination of the cost of each activity. Determining the costs of the monitoring activity was fairly easy because its costs were directly traceable. Lodging costs, however, are shared by two activities: lodging cardiology patients and lodging maternity care patients. The total lodging costs for the two activities were $3,800,000 per year and consisted of such items as building depreciation, building maintenance, and building utilities. The cardiology floor and the maternity floor each occupy 20,000 square feet. Carson determined that lodging costs would be assigned to each unit based on square feet.

To compute a daily rate that reflected the difference in demands, patients were placed in three categories according to illness severity, and the following annual data were collected:

Activity	*Cost of Activity*	*Activity Driver*	*Quantity*
Lodging	$1,900,000	Patient days	15,000
Monitoring	1,400,000	Monitoring hours used	20,000
Feeding	300,000	Patient days	15,000
Nursing care	3,000,000	Nursing hours	150,000
Total	$6,600,000		

The demands associated with patient severity are also provided:

Severity	*Patient Days*	*Monitoring Hours*	*Nursing Hours*
High	5,000	10,000	90,000
Medium	7,500	8,000	50,000
Low	2,500	2,000	10,000

Required:

1. Suppose that the costs of daily care are assigned using only patient days as the activity driver (which is also the measure of output). Compute the daily rate using this functional-based approach of cost assignment.
2. Compute activity rates using the given activity drivers (combine activities with the same driver).
3. Compute the charge per patient day for each patient type using the activity rates from Requirement 2 and the demands on each activity.
4. Suppose that the product is defined as “stay and treatment” where the treatment is bypass surgery. What additional information would you need to cost out this newly defined product?
5. Comment on the value of activity-based costing in service industries.

4-18 ACTIVITY-BASED COSTING, SERVICE FIRM

LO2, LO3 Glencoe First National Bank operated for years under the assumption that profitability can be increased by increasing dollar volumes. Historically, First National's efforts were directed toward increasing total dollars of sales and total dollars of account balances. In recent years, however, First National's profits have been eroding. Increased competition, particularly from savings and loan institutions, was the cause of the difficulties. As key managers discussed the bank's problems, it became apparent that they had no idea what their products were costing. Upon reflection, they realized that they had often made decisions to offer a new product, which promised to increase dollar balances without any consideration of what it cost to provide the service.

After some discussion, the bank decided to hire a consultant to compute the costs of three products: checking accounts, personal loans, and the gold VISA. The consultant identified the following activities, costs, and activity drivers (annual data):

Activity	*Activity Cost*	*Activity Driver*	*Activity Capacity*
Providing ATM service	$ 100,000	No. of transactions	200,000
Computer processing	1,000,000	No. of transactions	2,500,000
Issuing statements	88,000	No. of statements	55,000
Customer inquiries	360,000	Telephone minutes	600,000

The following annual information on the three products was also made available:

	Checking Accounts	*Personal Loans*	*Gold VISA*
Units of product	30,000	5,000	10,000
ATM transactions	180,000	0	20,000
Computer transactions	2,000,000	200,000	300,000
Number of statements	350,000	50,000	150,000
Telephone minutes	350,000	90,000	160,000

In light of the new cost information, Larry Roberts, the bank president, wanted to know whether a decision made two years ago to modify the bank's checking account product was sound. At that time, the service charge was eliminated on accounts with an average annual balance greater than $1,000. Based on increases in the total dollars in checking, Larry was pleased with the new product. The checking account product is described as follows: (1) Checking account balances greater than $500 earn interest of 2 percent per year, and (2) A service charge of $5 per month is charged for balances less than $1,000. The bank earns 4 percent on checking account deposits. Fifty percent of the accounts are less than $500 and have an average balance of $400 per account. Ten percent of the accounts are between $500 and $1,000 and average $750 per account. Twenty-five percent of the accounts are between $1,000 and $2,767; the average balance is $2,000. The remaining accounts carry a balance greater than $2,767. The average balance for these accounts is $5,000. Research indicates that the $2,000 category was by far the greatest contributor to the increase in dollar volume when the checking account product was modified two years ago.

Required:

1. Calculate rates for each activity.
2. Using the rates computed in Requirement 1, calculate the cost of each product.
3. Evaluate the checking account product. Are all accounts profitable? Compute the average annual profitability per account for the four categories of accounts

described in the problem. What recommendations would you make to increase the profitability of the checking account product?

4-19 Product Costing Accuracy, Corporate Strategy, ABC

LO2, LO3

Spreadsheet

Autotech Manufacturing is engaged in the production of replacement parts for automobiles. One plant specializes in the production of two parts: Part 127 and Part 234. Part 127 produced the highest volume of activity, and for many years it was the only part produced by the plant. Five years ago, Part 234 was added. Part 234 was more difficult to manufacture and required special tooling and setups. Profits increased for the first three years after the addition of the new product. In the last two years, however, the plant faced intense competition, and its sales of Part 127 dropped. In fact, the plant showed a small loss in the most recent reporting period. Much of the competition was from foreign sources, and the plant manager was convinced that the foreign producers were guilty of selling the part below the cost of producing it. The following conversation between Patty Goodson, plant manager, and Joseph Fielding, divisional marketing manager, reflects the concerns of the division about the future of the plant and its products.

JOSEPH: You know, Patty, the divisional manager is really concerned about the plant's trend. He indicated that in this budgetary environment, we can't afford to carry plants that don't show a profit. We shut one down just last month because it couldn't handle the competition.

PATTY: Joe, you and I both know that Part 127 has a reputation for quality and value. It has been a mainstay for years. I don't understand what's happening.

JOSEPH: I just received a call from one of our major customers concerning Part 127. He said that a sales representative from another firm offered the part at $20 per unit—$11 less than what we charge. It's hard to compete with a price like that. Perhaps the plant is simply obsolete.

PATTY: No. I don't buy that. From my sources, I know we have good technology. We are efficient. And it's costing a little more than $21 to produce that part. I don't see how these companies can afford to sell it so cheaply. I'm not convinced that we should meet the price. Perhaps a better strategy is to emphasize producing and selling more of Part 234. Our margin is high on this product, and we have virtually no competition for it.

JOSEPH: You may be right. I think we can increase the price significantly and not lose business. I called a few customers to see how they would react to a 25 percent increase in price, and they all said that they would still purchase the same quantity as before.

PATTY: It sounds promising. However, before we make a major commitment to Part 234, I think we had better explore other possible explanations. I want to know how our production costs compare to those of our competitors. Perhaps we could be more efficient and find a way to earn our normal return on Part 127. The market is so much bigger for this part. I'm not sure we can survive with only Part 234. Besides, my production people hate that part. It's very difficult to produce.

After her meeting with Joseph, Patty requested an investigation of the production costs and comparative efficiency. She received approval to hire a consulting group to make an independent investigation. After a 3-month assessment, the consulting group provided the following information on the plant's production activities and costs associated with the two products:

	Part 127	Part 234
Production	500,000	100,000
Selling price	$31.86	$24.00
Overhead per unit*	$12.83	$5.77
Prime cost per unit	$8.53	$6.26
Number of production runs	100	200
Receiving orders	400	1,000
Machine hours	125,000	60,000
Direct labor hours	250,000	22,500
Engineering hours	5,000	5,000
Material moves	500	400

*Calculated using a plantwide rate based on direct labor hours. This is the current way of assigning the plant's overhead to its products.

The consulting group recommended switching the overhead assignment to an activity-based approach. It maintained that activity-based cost assignment is more accurate and will provide better information for decision making. To facilitate this recommendation, it grouped the plant's activities into homogeneous sets with the following costs:

Setup costs	$ 240,000
Machine costs	1,750,000
Receiving costs	2,100,000
Engineering costs	2,000,000
Materials handling costs	900,000
Total	$6,990,000

Required:

1. Verify the overhead cost per unit reported by the consulting group using direct labor hours to assign overhead. Compute the per-unit gross margin for each product.
2. After learning of activity-based costing, Patty asked the controller to compute the product cost using this approach. Recompute the unit cost of each product using activity-based costing. Compute the per-unit gross margin for each product.
3. Should the company switch its emphasis from the high-volume product to the low-volume product? Comment on the validity of the plant manager's concern that competitors are selling below the cost of making Part 127.
4. Explain the apparent lack of competition for Part 234. Comment also on the willingness of customers to accept a 25 percent increase in price for Part 234.
5. Assume that you are the manager of the plant. Describe what actions you would take based on the information provided by the activity-based unit costs.

4-20 Activity-Based Costing, Reducing the Number of Drivers and Equal Accuracy

LO2, LO4

Reducir, Inc., produces two different types of hydraulic cylinders. Reducir produces a major subassembly for the cylinders in the cutting and welding department. Other parts and the subassembly are then assembled in the assembly department. The activities, expected costs, and drivers associated with these two manufacturing processes are as follows:

Process	*Activity*	*Cost*	*Activity Driver*	*Expected Quantity*
Cutting and welding	Welding	$ 776,000	Welding hours	4,000
	Machining	450,000	Machine hours	10,000
	Inspecting	448,250	No. of inspections	1,000
	Materials handling	300,000	No. of batches	12,000
	Setups	240,000	No. of setups	100
		$2,214,250		
Assembly	Changeover	$ 180,000	Changeover hours	1,000
	Rework	61,750	Rework orders	50
	Testing	300,000	No. of tests	750
	Materials handling	380,000	No. of parts	50,000
	Engineering support	130,000	Engineering hours	2,000
		$1,051,750		

Note: In the assembly process, the materials handling activity is a function of product characteristics rather than batch activity.

Other overhead activities, their costs, and drivers are as follows:

Activity	*Cost*	*Activity Driver*	*Quantity*
Purchasing	$135,000	Purchase requisitions	500
Receiving	274,000	Receiving orders	2,000
Paying suppliers	225,000	No. of invoices	1,000
Providing space and utilities	100,000	Machine hours	10,000
	$734,000		

Other production information concerning the two hydraulic cylinders is also provided as follows:

	Cylinder A	*Cylinder B*
Units produced	1,500	3,000
Welding hours	1,600	2,400
Machine hours	3,000	7,000
Inspections	500	500
Moves	7,200	4,800
Batches	45	55
Changeover hours	540	460
Rework orders	5	45
Tests	500	250
Parts	40,000	10,000
Engineering hours	1,500	500
Requisitions	425	75
Receiving orders	1,800	200
Invoices	650	350

Required:

1. Using a plantwide rate based on machine hours, calculate the total overhead cost assigned to each product and the unit overhead cost.
2. Using activity rates, calculate the total overhead cost assigned to each product and the unit overhead cost. Comment on the accuracy of the plantwide rate.

3. Calculate the global consumption ratios.
4. Calculate the consumption ratios for welding and materials handling (assembly) and show that two drivers, welding hours and number of parts, can be used to achieve the same ABC product costs calculated in Requirement 2. Explain the value of this simplification.
5. Calculate the consumption ratios for inspection and engineering and show that the drivers for these two activities also duplicate the ABC product costs calculated in Requirement 2.

4-21 Approximately Relevant ABC

LO4 Refer to the data given in **Problem 4-20** and suppose that the expected activity costs are reported as follows (all other data remain the same):

Process	*Activity*	*Cost*
Cutting and welding	Welding	$2,000,000
	Machining	1,000,000
	Inspecting	50,000
	Materials handling	72,000
	Setups	400,000
		$3,522,000
Assembly	Changeover	$ 28,000
	Rework	50,000
	Testing	40,000
	Materials handling	60,000
	Engineering support	70,000
		$ 248,000

Other overhead activities:

Activity	*Cost*
Purchasing	$ 50,000
Receiving	70,000
Paying suppliers	80,000
Providing space and utilities	30,000
	$230,000

The per-unit overhead costs using the 14 activity-based drivers are $1,108 and $779 for Cylinder A and Cylinder B, respectively.

Required:

1. Determine the percentage of total costs represented by the three most expensive activities.
2. Allocate the costs of all other activities to the three activities identified in Requirement 1. Allocate the other activity costs to the three activities in proportion to their individual activity costs. Now assign these total costs to the products using the drivers of the three chosen activities.
3. Using the costs assigned in Requirement 1, calculate the percentage error using the ABC costs as a benchmark. Comment on the value and advantages of this ABC simplification.

4-22 ABC and Relational Tables

LO5 BKM Foundry manufactures different kinds of equipment used by the aerospace, commercial aircraft, and electronic industries. Twenty different products are created using two major manufacturing processes: molding and assembly. The procurement and sustaining processes are also used in the plant. The activity and product relational tables follow (for simplicity, only two products of the 20 produced are shown in the product relational table):

Activity Relational Table: BKM Foundry

Activity Number	*Activity Name*	*Process*	*Level*	*Activity Driver*	*Activity Capacity*	*Cost*
1	Designing molds	Molding	Product	No. of products	20	$600,000
2	Making molds	Molding	Product	No. of products	20	320,000
3	Inspecting molds	Molding	Batch	No. of setups	400	120,000
4	Setting up batches	Molding	Batch	No. of setups	400	120,000
5	Engineering design	Assembly	Product	Change orders	40	130,000
6	Materials handling	Assembly	Batch	No. of subassemblies	400	90,000
7	Machining	Assembly	Unit	Machine hours	200,000	225,000
8	Purchasing materials	Procurement	Batch	Purchase orders	1,000	200,000
9	Receiving materials	Procurement	Batch	Purchase orders	1,000	320,000
10	Paying suppliers	Procurement	Product	No. of molds	20,000	180,000
11	Providing utilities	Sustaining	Facility	Machine hours	20,000	20,000
12	Providing space	Sustaining	Facility	Machine hours	20,000	50,000

Product Relational Table: BKM Foundry

Product Number	*Product Name*	*Activity Driver Number*	*Activity Driver Name*	*Activity Usage*
1	Component A	1	Units	1,000
1	Component A	2	No. of molds	2,000
1	Component A	3	No. of setups	10
1	Component A	4	Change orders	4
1	Component A	5	No. of products	1
1	Component A	6	Purchase orders	50
1	Component A	7	No. of subassemblies	2
1	Component A	8	Machine hours	800
2	Component B	1	Units	2,000
2	Component B	2	No. of molds	6,000
2	Component B	3	No. of setups	20
2	Component B	4	Change orders	3
2	Component B	5	No. of products	1
2	Component B	6	Purchase orders	60
2	Component B	7	No. of subassemblies	3
2	Component B	8	Machine hours	1,000

Required:

1. Describe how activity and product relational tables are created.
2. Using the preceding tables, provide examples of the following:
   a. Primary key
   b. Concatenated key

c. Record
d. Activity attribute
e. Product attribute
f. Entity

3. Using the information from the relational tables, calculate activity rates for the molding process. Combine activities with the same driver into one cost pool.
4. Using the activity rates computed in Requirement 3, assign molding process costs to Component A. What is the molding overhead cost per unit?

4-23 Product Costing Accuracy, Plantwide and Departmental Rates, ABC

LO1, LO2, LO3

Springs Company produces two type of calculators: scientific and business. Both products pass through two producing departments. The business calculator is by far the most popular. The following data have been gathered for these two products:

Product-Related Data

	Scientific	*Business*
Units produced per year	30,000	300,000
Prime costs	$100,000	$1,000,000
Direct labor hours	40,000	400,000
Machine hours	20,000	200,000
Production runs	40	60
Inspection hours	800	1,200
Maintenance hours	900	3,600

Department Data

	Department 1	*Department 2*
Direct labor hours:		
Scientific calculator	30,000	10,000
Business calculator	45,000	355,000
Total	75,000	365,000
Machine hours:		
Scientific calculator	10,000	10,000
Business calculator	160,000	40,000
Total	170,000	50,000
Overhead costs:		
Setup costs	$ 90,000	$ 90,000
Inspection costs	70,000	70,000
Power	100,000	60,000
Maintenance	80,000	100,000
Total	$340,000	$320,000

Required:

1. Compute the overhead cost per unit for each product using a plantwide, unit-based rate.

2. Compute the overhead cost per unit for each product using departmental rates. In calculating departmental rates, use machine hours for department 1 and direct labor hours for department 2. Repeat using direct labor hours for department 1 and machine hours for department 2.
3. Compute the overhead cost per unit for each product using activity-based costing.
4. Comment on the ability of departmental rates to improve the accuracy of product costing.

4-24 Collaborative Learning Exercise

LO2, LO3

Primo Paper, Inc., has three paper mills, one of which is located in Seattle, Washington. The Seattle mill produces 200 different types of coated and uncoated specialty printing papers. This large variety of products was the result of a full-line marketing strategy adopted by Primo's management. Management was convinced that the value of variety more than offset the extra costs of the increased complexity.

During 2007, the Seattle mill produced 240,000 tons of coated paper and 160,000 tons of uncoated stock. Of the 400,000 tons produced, 360,000 were sold. Thirty different products account for 80 percent of the tons sold. Thus, 170 products are classified as low-volume products.

Lightweight lime hopsack in cartons (LLHC) is one of the low-volume products. LLHC is produced in rolls, converted into sheets of paper, and then sold in cartons. In 2007, the cost to produce and sell one ton of LLHC was as follows:

Direct materials:		
Pulps	2,225 pounds	$ 540
Additives (11 different items)	200 pounds	600
Tub size	75 pounds	12
Recycled scrap paper	296 pounds	(24)
Total direct materials		$1,128
Direct labor		$ 540
Overhead:		
Paper machine (1.25 tons @ $120 per ton)		$ 150
Finishing machine (1.25 tons @ $144 per ton)		180
Total overhead		$ 330
Shipping and warehousing		$ 36
Total manufacturing and selling cost		$2,034

Overhead is applied using a 2-stage process. First, overhead is allocated to the paper and finishing machines using the direct method of allocation with carefully selected activity drivers. Second, the overhead assigned to each machine is divided by the budgeted tons of output. These rates are then multiplied by the number of tons required to produce one good ton.

In 2007, LLHC sold for $2,500 per ton, making it one of the most profitable products. A similar examination of some of the other low-volume products revealed that they also had very respectable profit margins. Unfortunately, the performance of the high-volume products was less impressive, with many showing losses or very low profit margins. This situation led Emily Hansen to call a meeting with her marketing vice president, Natalie Nabors, and her controller, Carson Chesser. Their conversation follows.

EMILY: The above-average profitability of our low-volume specialty products and the poor profit performance of our high-volume products make me believe that we should switch our marketing emphasis to the low-volume line. Perhaps we should drop some of our high-volume products, particularly those showing a loss.

NATALIE: I'm not convinced that the solution you are proposing is the right one. I know our high-volume products are of high quality, and I am convinced that we are as efficient in our production as other firms. I think that somehow our costs are not being assigned correctly. For example, the shipping and warehousing costs are assigned by dividing these costs by the total tons of paper sold. Yet . . .

CARSON: Natalie, I hate to disagree, but the $36 per ton charge for shipping and warehousing seems reasonable. I know that our method to assign these costs is identical to a number of other paper companies.

NATALIE: Well, that may be true, but do these other companies have the variety of products that we have? Our low-volume products require special handling and processing, but when we assign shipping and warehousing costs, we average these special costs across our entire product line. Every ton produced in our mill passes through our mill shipping department and is either sent directly to the customer or to our distribution center and then eventually to customers. My records indicate quite clearly that virtually all the high-volume products are sent directly to customers, whereas most of the low-volume products are sent to the distribution center. Now all the products passing through the mill shipping department should receive a share of the $4,000,000 annual shipping costs. Yet, as currently practiced, all products receive a share of the receiving and shipping costs of the distribution center.

EMILY: Carson, is this true? Does our system allocate our shipping and warehousing costs in this way?

CARSON: Yes, I'm afraid it does. Natalie may have a point. Perhaps we need to reevaluate our method to assign these costs to the product lines.

EMILY: Natalie, do you have any suggestions concerning how the shipping and warehousing costs ought to be assigned?

NATALIE: It seems reasonable to make a distinction between products that spend time in the distribution center and those that do not. We should also distinguish between the receiving and shipping activities at the distribution center. All incoming shipments are packed on pallets and weigh one ton each. (There are 14 cartons of paper per pallet.) In 2007, receiving processed 112,000 tons of paper. Receiving employs 50 people at an annual cost of $2,400,000. Other receiving costs total about $2,000,000. I would recommend that these costs be assigned using tons processed. Shipping, however, is different. There are two activities associated with shipping: picking the order from inventory and loading the paper. We employ 60 people for picking and 35 for loading at an annual cost of $4,800,000. Other shipping costs total $4,400,000. Picking and loading are more concerned with the number of shipping items rather than tonnage. That is, a shipping item may consist of two or three cartons instead of pallets. Accordingly, the shipping costs of the distribution center should be assigned using the number of items shipped. In 2007, for example, we handled 380,000 shipping items.

EMILY: These suggestions have merit. Carson, I would like to see what effect Natalie's suggestions have on the per-unit assignment of shipping and warehousing for LLHC. If the effect is significant, then we will expand the analysis to include all products.

CARSON: I'm willing to compute the effect, but I'd like to suggest one additional feature. Currently, we have a policy to carry about three tons of LLHC in inventory. Our current costing system totally ignores the cost of carrying this inventory. Since it costs us $1,998 to produce each ton of this product, we are tying up a lot of money in inventory—money that could be invested in other productive opportunities. In fact, the return lost is about 14 percent per year. This cost should also be assigned to the units sold.

EMILY: Carson, this also sounds good to me. Go ahead and include the carrying cost in your computation.

To help in the analysis, Carson gathered the following data for LLHC for 2007:

Tons sold	10
Average cartons per shipment	2
Average shipments per ton	7

Required:

Work through the requirements below before coming to class. Next, form groups of three to four students, and compare and contrast the answers within the group. Finally, form modified groups by exchanging one member of your group with a member of another group. The modified groups will compare and contrast each group's answers to the requirements.

1. Identify the flaws associated with the current method to assign shipping and warehousing costs to Primo's products.
2. Compute the shipping and warehousing costs per ton of LLHC sold using the new method suggested.
3. Using the new costs computed in Requirement 2, compute the profit per ton of LLHC. Compare this with the profit per ton computed using the old method. Do you think that this same effect would be realized for other low-volume products? Explain.
4. Comment on Emily's proposal to drop some high-volume products and place more emphasis on low-volume products. Discuss the role of the accounting system in supporting this type of decision making.
5. After receiving the analysis of LLHC, Emily decided to expand the analysis to all products. She also asked Carson to reevaluate the way in which mill overhead was assigned to products. After the restructuring was completed, Emily took the following actions: (a) the prices of most low-volume products were increased, (b) the prices of several high-volume products were decreased, and (c) some low-volume products were dropped. Explain why Emily's strategy changed so dramatically.

4-25 Cyber Research Case

LO5

ABC software is a critical component of an ABC system implementation. ABC software produces the results that will be used by decision makers. Thus, the capabilities of ABC software are extremely important. The choice of ABC software can have a dramatic effect on the success or failure of an organization's ABC initiative. Non-ERP companies may choose stand-alone ABC software packages. Depending on the size of the application, PC software may be adequate.

The emergence of ERP systems (and, of course, ERP software) is also having an effect on ABC software selection. ERP companies will not usually choose stand-alone ABC software. Essentially, ERP systems demand some form of integration. Two choices are available for achieving this integration:

a. An ERP system that has an add-on module.
b. ABC software that has linking and importing capabilities to establish a bridge between the two systems.

Required:

1. Using an Internet search, identify three stand-alone software packages that have the following features:
   a. Windows 98 or higher platform or Windows NT platform
   b. ABC budgeting

c. Excel interface
d. Data export
e. Profit analysis
f. Resource, activity, and cost object modules and possibly more

After identifying software with the above features, which would you select? Why? Are there other important features that you read about that you would like to include as part of the selection criteria?

2. ERP and ABC vendors have joined forces in creating an ABC-ERP partnership. Examples include the following:
   a. SAP's acquistion of ABC Technologies
   b. Armstrong-Laing and JD Edwards

   Search the Internet for two online articles that discuss ABC and ERP software issues. Write a brief summary of each article.