CHAPTER 15

Productivity Measurement and Control

AFTER STUDYING THIS CHAPTER, YOU SHOULD BE ABLE TO:

1. Explain the meaning of productive efficiency, and describe the difference between technical and allocative efficiency.
2. Define partial productivity measurement, and list its advantages and disadvantages.
3. Explain what total productivity measurement is, and name its advantages.
4. Discuss the role of productivity measurement in assessing activity improvement.

Technology often leads to increases in labor productivity. Laptops, for example, may allow workers to solve problems on the spot and reduce the amount of lost production time. Producing more with the same or less inputs often promises significant increases in profitability.

Continuous improvement implies that efficiency is increasing over time. In fact, to be competitive, organizations must increase efficiency. An organization must be as good or better than its competitors at taking materials, labor, machines, power, and other inputs and turning out high-quality goods and services. A company can create a competitive advantage by using fewer inputs to produce a given output or by producing more output for a given set of inputs. Management needs to assess the potential and actual effectiveness of decisions that are geared to improve efficiency. Management also needs to monitor and control efficiency changes. Efficiency measures satisfy these performance and control objectives. In previous chapters, various approaches to measuring efficiency have been presented. For example, we have presented and discussed such measurement approaches as value-added and non-value-added cost reports, trends in cost, and activity flexible budgeting. In this chapter, we will explore efficiency measures that are concerned with the relationship of inputs and outputs, referred to as *productivity measures.*

OBJECTIVE 1

Explain the meaning of productive efficiency, and describe the difference between technical and allocative efficiency.

Productive Efficiency

Productivity is concerned with producing output efficiently, and it specifically addresses the relationship of output and the inputs used to produce the output. Usually, different combinations or mixes of inputs can be used to produce a given level of output. **Total productive efficiency** is the point at which two conditions are satisfied: (1) for any mix of inputs that will produce a given output, no more of any one input is used than necessary to produce the output and (2) given the mixes that satisfy the first condition, the least costly mix is chosen. The first condition is driven by technical relationships and, therefore, is referred to as **technical efficiency**. Viewing activities as inputs, the first condition requires the elimination of all non-value-added activities and requires that value-added activities be performed with the minimal quantities needed to produce the given output. The second condition is driven by relative input price relationships and, therefore, is referred to as **allocative efficiency**. Input prices determine the *relative proportions* of each input that should be used. Deviation from these fixed proportions creates allocative inefficiency.

Productivity improvement programs involve moving toward a state of total productive efficiency. Technical improvements in productivity can be achieved by using fewer inputs to produce the same output, by producing more output using the same inputs, or by producing more output with relatively fewer inputs. For example, in 2002, the Lansing C Michigan plant of **General Motors** (GM) used 20.11 hours per vehicle (Pontiac Grand Am and Oldsmobile Alero); in 2003, the Lansing C Michigan plant used 1864 hours per vehicle. Thus, labor productivity increased by 7.3 percent.[1] Exhibit 15-1, on the following page, illustrates the three ways to achieve an improvement in technical efficiency. The output is vehicles, and the inputs are labor (number of workers) and capital (dollars invested in automated equipment). Notice that the relative proportions of the inputs are held constant so that all productivity improvement is attributable to improving technical efficiency. Productivity improvement can also be achieved by trading off more costly inputs for less costly inputs. Exhibit 15-2, on page 667, illustrates the possibility of improving productivity by increasing allocative efficiency. Although improving technical efficiency is what most people think of when improving productivity is mentioned, allocative efficiency can offer significant opportunities for increasing overall economic efficiency. Choosing the right combination of inputs can be as critical as choosing the right quantity of inputs. Notice in Exhibit 15-2 that input Combination I produces the same output as input Combination II but that the cost is $5,000,000 less. Total measures of productivity are usually a combination of changes in technical and allocative efficiency.

OBJECTIVE 2

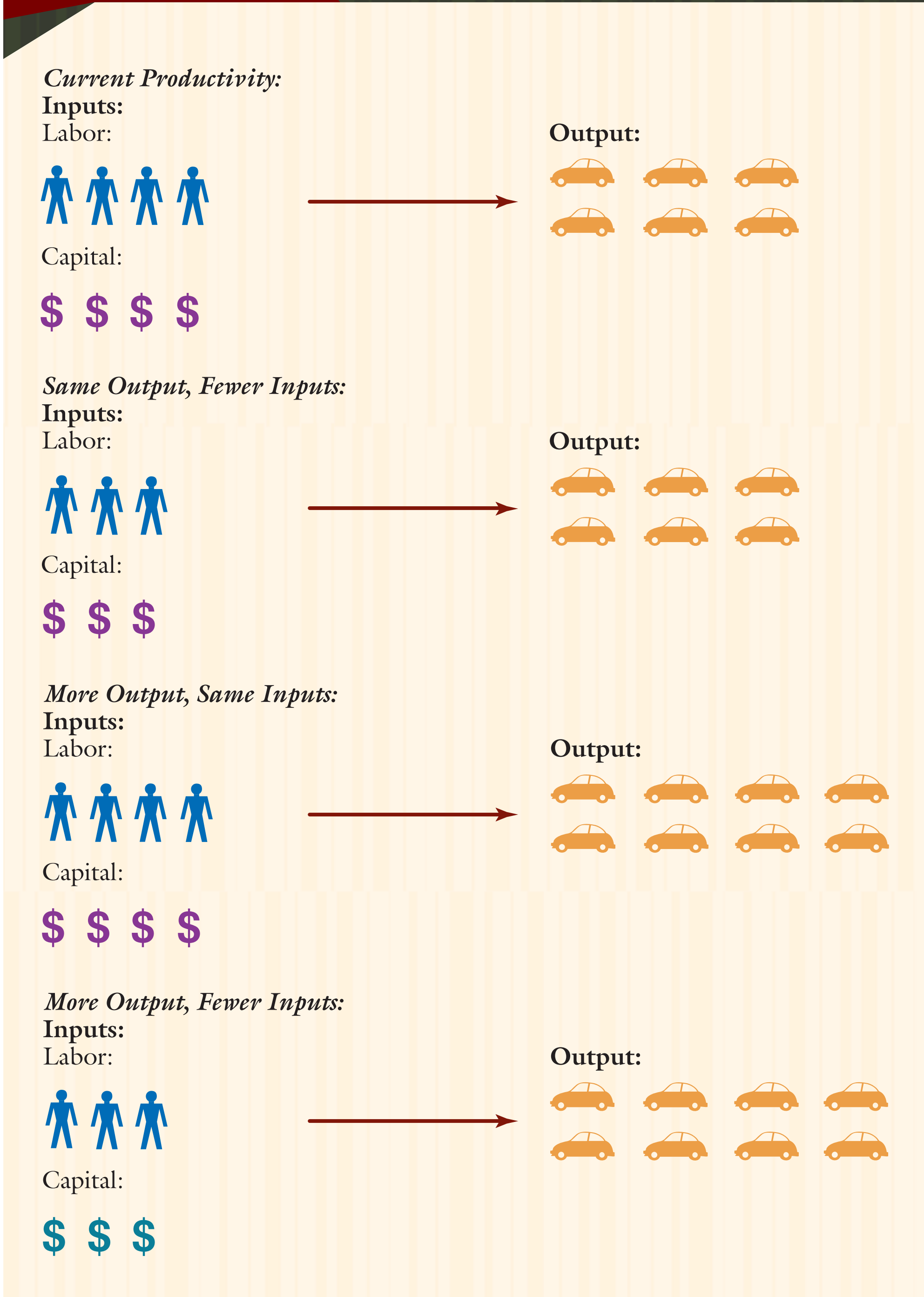
Define partial productivity measurement, and list its advantages and disadvantages.

Partial Productivity Measurement

Productivity measurement is simply a quantitative assessment of productivity changes. The objective is to assess whether productive efficiency has increased or decreased. Productivity measurement can be actual or prospective. Actual productivity measurement allows managers to assess, monitor, and control changes. Prospective measurement is forward-looking, and it serves as input for strategic decision making. Specifically, prospective measurement allows managers to compare relative benefits of different input combinations, choosing the inputs and input mix that provide the greatest benefit. Productivity measures can be developed for each input separately or for all inputs jointly. Measuring productivity for one input at a time is called **partial productivity measurement**.

1. Harbour Report (2203 and 2003), http://www.autointell.com, accessed Nov. 4, 2004.

EXHIBIT 15-1 Improving Technical Efficiency



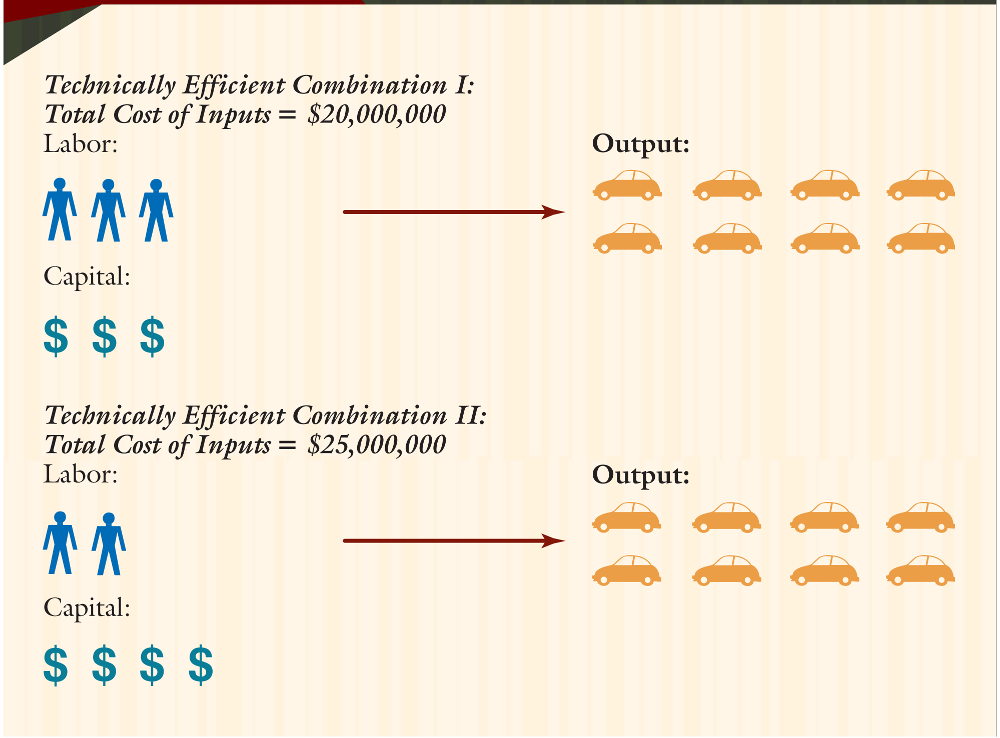
Partial Productivity Measurement Defined

Productivity of a single input is typically measured by calculating the ratio of the output to the input as follows:

$$\text{Productivity ratio} = \text{Output}/\text{Input}$$

Because the productivity of only one input is being measured, the measure is called a *partial productivity measure*. If both output and input are measured in physical quan-

EXHIBIT 15-2 Allocative Efficiency



tities, then we have an **operational productivity measure**. If output or input is expressed in dollars, then we have a **financial productivity measure**.

Assume, for example, that in 2006, Nevada Company produced 240,000 frames for snowmobiles and used 60,000 hours of labor. The labor productivity ratio is four frames per hour (240,000/60,000). This is an operational measure, since the units are expressed in physical terms. If the selling price of each frame is $30 and the cost of labor is $15 per hour, then output and input can be expressed in dollars. The labor productivity ratio, expressed in financial terms, is $8 of revenue per dollar of labor cost ($7,200,000/$900,000).

Partial Measures and Measuring Changes in Productive Efficiency

The labor productivity ratio of four frames per hour measures the 2006 productivity experience of Nevada. By itself, the ratio conveys little information about productive efficiency or whether the company has improving or declining productivity. It is possible, however, to make a statement about increasing or decreasing productivity efficiency by measuring *changes* in productivity. To do so, the actual current productivity measure is compared with the productivity measure of a prior period. This prior period is referred to as the **base period** and serves to set the benchmark or standard for measuring changes in productive efficiency. The prior period can be any period desired. It could, for example, be the preceding year, the preceding week, or even the period during which the last batch of products was produced. For strategic evaluations, the base period is usually chosen as an earlier year. For operational control, the base period tends to be close to the current period—such as the preceding batch of products or the preceding week.

To illustrate, assume that 2006 is the base period and that the labor productivity standard, therefore, is four frames per hour. Further assume that late in 2006, Nevada decided to try a new procedure for producing and assembling the frames with the expectation that the new procedure would use less labor. In 2007, 250,000 frames were produced, using 50,000 hours of labor. The labor productivity ratio for 2007 is five frames per hour (250,000/50,000). The *change* in productivity is a one-unit-per-hour *increase* in productivity (from four units per hour in 2006 to five units per hour in 2007). The change is a significant improvement in labor productivity and provides evidence supporting the efficacy of the new process.

Advantages of Partial Measures

Partial measures allow managers to focus on the use of a particular input. Operating partial measures have the advantage of being easily interpreted by everyone within the organization. Consequently, partial operational measures are easy to use for assessing productivity performance of operating personnel. Laborers, for instance, can relate to units produced per hour or units produced per pound of material. Thus, partial operational measures provide feedback that operating personnel can relate to and understand—measures that deal with the specific inputs over which they have control. The ability of operating personnel to understand and relate to the measures increases the likelihood that the measures will be accepted. Furthermore, for operational control, the standards for performance are often very short run in nature. For example, standards can be the productivity ratios of prior batches of goods. Using this standard, productivity trends within the year itself can be tracked.

Disadvantages of Partial Measures

Partial measures, used in isolation, can be misleading. A decline in the productivity of one input may be necessary to increase the productivity of another. Such a trade-off is desirable if overall costs decline, but the effect would be missed by using either partial measure. For example, changing a process so that direct laborers take less time to assemble a product may increase scrap and waste while leaving total output unchanged. Labor productivity has increased, but productive use of materials has declined. If the increase in the cost of waste and scrap outweighs the savings of the decreased labor, then overall productivity has declined.

Two important conclusions can be drawn from this example. First, the possible existence of trade-offs mandates a total measure of productivity for assessing the merits of productivity decisions. Only by looking at the total productivity effect of all inputs can managers accurately draw any conclusions about overall productivity performance. Second, because of the possibility of trade-offs, a total measure of productivity must assess the aggregate financial consequences and, therefore, should be a financial measure.

Total Productivity Measurement

OBJECTIVE 3

Explain what total productivity measurement is, and name its advantages.

Measuring productivity for all inputs at once is called **total productivity measurement**. In practice, it may not be necessary to measure the effect of all inputs. Many firms measure the productivity of only those factors that are thought to be relevant indicators of organizational performance and success. Thus, in practical terms, total productivity measurement can be defined as focusing on a limited number of inputs, which, in total, indicates organizational success. In either case, total productivity measurement requires the development of a multifactor measurement approach. A common multifactor approach suggested in the productivity literature (but rarely found in practice) is the use of aggregate productivity indices. Aggregate indices are complex and difficult to interpret and have not been generally accepted. Two approaches that have gained some acceptance are *profile measurement* and *profit-linked productivity measurement.*

Profile Productivity Measurement

Producing a product involves numerous critical inputs such as labor, materials, capital, and energy. **Profile measurement** provides a series or vector of separate and distinct partial operational measures. Profiles can be compared over time to provide information about productivity changes. To illustrate the profile approach, we will use only two inputs: labor and materials. Let's return to the Nevada Company example. As before, Nevada implements a new production and assembly process in 2007. Only now, let's assume that the new process affects both labor and materials. Initially, let's look at the case for which the productivity of both inputs moves in the same direction. The following data for 2006 and 2007 are available:

	2006	*2007*
Number of frames produced	240,000	250,000
Labor hours used	60,000	50,000
Materials used (lbs.)	1,200,000	1,150,000

COST MANAGEMENT Technology in Action

Information technology can be the source of significant productivity gains. **International Paper**, a large company with about 200,000 employees, stores information about factory operations, customers, suppliers, etc. The total data stored reportedly take up approximately 25 terabytes of storage space, enough to fill 2,500 trucks. Because of its importance, 191 technicians were spending about half their time backing up the data. An investment in an instant backup system provided by EMC significantly cut labor costs. The daily backup routines were reduced from 10 hours to 15 minutes. This reduced the required number of technicians by almost 50 percent. It is difficult to imagine an unfavorable trade-off between capital and labor in this instance! The savings from eliminating the salaries of 95 technicians promise a quick recovery of the capital investment in an instant backup system.

Source: Adam Cohen, "Spending to Save," an online article at http://www.time.com/time/global, Sunday, April 1, 2001 edition.

Exhibit 15-3 provides productivity ratio profiles for each year. The 2006 profile is (4, 0.200), and the 2007 profile is (5, 0.217). Comparing profiles for the two years, we can see that productivity increased for both labor and materials (from 4 to 5 for labor and from 0.200 to 0.217 for materials). The profile comparison provides enough information for a manager to conclude that the new assembly process has definitely improved overall productivity. The *value* of this improvement, however, is not revealed by the ratios.

EXHIBIT 15-3 Productivity Measurement: Profile Analysis, No Trade-Offs

Partial Operational Productivity Ratios	2006 Profile[a]	2007 Profile[b]
Labor productivity ratio	4.000	5.000
Material productivity ratio	0.200	0.217

[a]Labor: 240,000/60,000; Materials: 240,000/1,200,000.
[b]Labor: 250,000/50,000; Materials: 250,000/1,150,000.

As just shown, profile analysis can provide managers with useful insights about changes in productivity. However, comparing productivity profiles will not always reveal the nature of the overall change in productive efficiency. In some cases, profile analysis will not provide any clear indication of whether a productivity change is good or bad. To illustrate, let's revise the Nevada Company data to allow for trade-offs among the two inputs. Assume that all the data are the same except for materials used in 2007. Let the materials used in 2007 be 1,300,000 pounds. Using this revised number, the productivity profiles for 2006 and 2007 are presented in Exhibit 15-4. The productivity profile for 2006 is still (4, 0.200), but the profile for 2007 has changed to (5, 0.192). Comparing productivity profiles now provides a mixed signal. Productivity for labor has increased from 4 to 5, but productivity for materials has decreased from 0.200 to 0.192. The new process has caused a trade-off in the productivity for the two measures. Furthermore, while a profile analysis reveals that the trade-off exists, it does not reveal whether the trade-off is good or bad. If the economic effect of the productivity changes is positive, then the trade-off is good; otherwise, it must be viewed as bad.

EXHIBIT 15-4 **Productivity Measurement: Profile Analysis with Trade-Offs**

Partial Operational Productivity Ratios	2006 Profile[a]	2007 Profile[b]
Labor productivity ratio	4.000	5.000
Material productivity ratio	0.200	0.192

[a]Labor: 240,000/60,000; Materials: 240,000/1,200,000.
[b]Labor: 250,000/50,000; Materials: 250,000/1,300,000.

Valuing the trade-offs would allow us to assess the economic effect of the decision to change the assembly process. Furthermore, by valuing the productivity change, we obtain a total measure of productivity.

Profit-Linked Productivity Measurement

Assessing the effects of productivity changes on current profits is one way to value productivity changes. Profits change from the base period to the current period. Some of that profit change is attributable to productivity changes. Measuring the amount of profit change attributable to productivity change is defined as **profit-linked productivity measurement**.

Assessing the effect of productivity changes on current-period profits will help managers understand the economic importance of productivity changes. Linking productivity changes to profits is described by the following rule:

> **Profit-Linkage Rule.** *For the current period, calculate the cost of the inputs that would have been used in the absence of any productivity change and compare this cost with the cost of the inputs actually used. The difference in costs is the amount by which profits changed because of productivity changes.*

To apply the linkage rule, the inputs that would have been used for the current period in the absence of a productivity change must be calculated. Let PQ represent this productivity-neutral quantity of input. To determine the productivity-neutral quantity for a particular input, divide the current-period output by the input's base-period productivity ratio:

$$PQ = \text{Current-period output/Base-period productivity ratio}$$

To illustrate the application of the profit-linked rule, let's return to the Nevada example with input trade-offs. We must add some cost information to the data. The expanded Nevada data set is as follows:

	2006	2007
Number of frames produced	240,000	250,000
Labor hours used	60,000	50,000
Materials used (lbs.)	1,200,000	1,300,000
Unit selling price (frames)	$30	$30
Wages per labor hour	$15	$15
Cost per pound of material	$3	$3.50

Current output (2007) is 250,000 frames. From Exhibit 15-4, we know that the base-period productivity ratios are 4 and 0.200 for labor and materials, respectively. Using this information, the productivity-neutral quantity for each input is computed as follows:

$$PQ\text{ (labor)} = 250{,}000/4 = 62{,}500\text{ hrs.}$$
$$PQ\text{ (materials)} = 250{,}000/0.200 = 1{,}250{,}000\text{ lbs.}$$

For our example, *PQ* gives labor and material inputs that *would have been used* in 2007, assuming no productivity change. What the cost would have been for these productivity-neutral quantities in 2007 is computed by multiplying each individual input quantity (*PQ*) by its current price (*P*) and adding:[2]

Cost of labor: $PQ \times P = 62{,}500 \times \$15 =$	$ 937,500
Cost of materials: $PQ \times P = 1{,}250{,}000 \times \$3.50 =$	4,375,000
Total *PQ* cost	$5,312,500

The actual cost of inputs is obtained by multiplying the actual quantity (*AQ*) by current input price (*P*) for each input and adding:

Cost of labor: $AQ \times P = 50{,}000 \times \$15 =$	$ 750,000
Cost of materials: $AQ \times P = 1{,}300{,}000 \times \$3.50 =$	4,550,000
Total current cost	$5,300,000

Finally, the productivity effect on profits is computed by subtracting the total current cost from the total *PQ* cost as follows:

$$\begin{aligned}\text{Profit-linked effect} &= \text{Total } PQ \text{ cost} - \text{Total current cost}\\ &= \$5{,}312{,}500 - \$5{,}300{,}000\\ &= \$12{,}500 \text{ increase in profits}\end{aligned}$$

The calculation of the profit-linked effect is summarized in Exhibit 15-5 on the following page.

The summary in Exhibit 15-5 reveals that the net effect of the process change was favorable. Profits increased by $12,500 because of the productivity changes. Notice also that profit-linked productivity effects can be assigned to individual inputs. The increase in labor productivity creates a $187,500 increase in profits; however, the drop in materials productivity caused a $175,000 decrease in profits. Most of the profit decrease came from an increase in materials usage—apparently, waste, scrap, and spoiled units are much greater with the new process. Thus, the profit-linked measure provides partial measurement effects as well as a total measurement effect. The total profit-linked productivity measure is the sum of the individual partial measures. This property makes the profit-linked measure ideal for assessing trade-offs. A much clearer picture of the effects of the changes in productivity emerges. Unless waste and scrap can be brought under better control, the company ought to return to the old assembly process. Of

2. Base-period input prices are frequently used to value productivity changes. However, it has been shown that current input prices provide more accurate profit-linked productivity measurement. See Hansen, Mowen, and Hammer, "Profit-Linked Productivity Measurement," *Journal of Management Accounting Research* (Fall 1992): 79–98.

EXHIBIT 15-5 Profit-Linked Productivity Measurement

Input	(1) PQ*	(2) $PQ \times P$	(3) AQ	(4) $AQ \times P$	(2) − (4) $(PQ \times P) - (AQ \times P)$
Labor	62,500	$ 937,500	50,000	$ 750,000	$ 187,500
Materials	1,250,000	4,375,000	1,300,000	4,550,000	(175,000)
		$5,312,500		$5,300,000	$ 12,500

*Labor: 250,000/4; Materials: 250,000/0.200.

course, it is possible that the learning effects of the new process are not yet fully captured and further improvements in labor productivity might be observed. As labor becomes more proficient at the new process, it is possible that the materials usage could also decrease.

Price-Recovery Component

The profit-linked measure computes the amount of profit change from the base period to the current period attributable to productivity changes. Generally, this will not be equal to the total profit change between the two periods. The difference between the total profit change and the profit-linked productivity change is called the **price-recovery component**. This component is the change in revenue less a change in the cost of inputs, *assuming no productivity changes.* It, therefore, measures the ability of revenue changes to cover changes in the cost of inputs, assuming no productivity change.

To calculate the price-recovery component, we first need to compute the change in profits for each period. This computation is as follows:

	2006	*2007*	*Difference*
Revenues	$7,200,000	$7,500,000	$ 300,000
Cost of inputs	4,500,000	5,300,000	(800,000)
Profit	$2,700,000	$2,200,000	$(500,000)

Price-recovery = Profit change − Profit-linked productivity change
= ($500,000) − $12,500
= ($512,500)

The increase in revenues would not have been sufficient to recover the increase in the cost of the inputs. The increase in productivity provided some relief for the price-recovery problem. Increases in productivity can be used to offset price-recovery losses.

Measuring Changes in Activity and Process Efficiency

OBJECTIVE 4

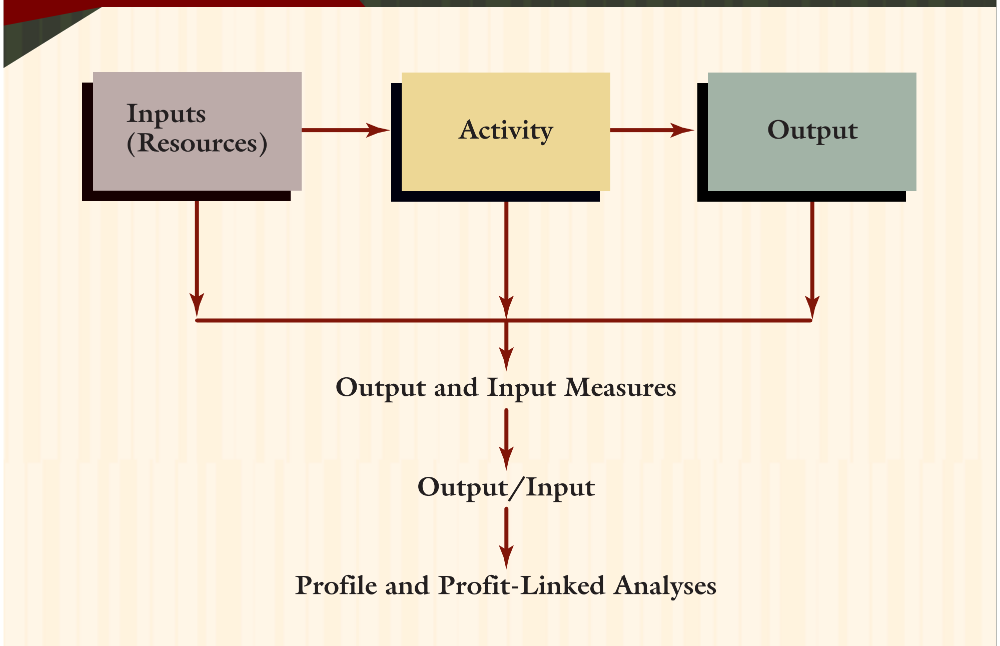
Discuss the role of productivity measurement in assessing activity improvement.

An activity-based responsibility accounting system focuses on improving the efficiency of processes and activities. As we have just seen, it is possible to measure the value of changes in productive efficiency by analyzing changes in input and output relationships over time. Although the analysis was done for products produced and sold, the same concepts can be applied to any type of output. Activities, for example, consume inputs such as labor, materials, and energy, and they produce an output such as hours of inspection or number of setups. Thus, it is possible to measure changes in activity productive efficiency. Measuring changes in activity efficiency can be an important part of an activity-based management system. **Activity productivity analysis** is an approach that directly measures changes in activity productivity. Similarly, a process produces an output, and it is also possible to measure process productivity. In fact, since processes are collections of activities with a common goal, activity productivity changes must affect process productivity. **Process productivity analysis** measures changes in process productivity.

Activity Productivity Analysis

An activity can be viewed as an entity that transforms inputs into an output. The inputs are the resources consumed by an activity. Recall that resources are the economic elements that allow an activity to be performed. Thus, in effect, resources are the inputs or factors of production that are used by an activity to create its output. These inputs or resources are identical in concept to the factors used to produce a product: materials, labor, capital, energy, etc. Accordingly, the key to activity productivity analysis is defining activity output and an appropriate activity output measure. Once the output measure is identified, then both profile and profit-linked productivity analyses are possible. Exhibit 15-6 illustrates the activity model that provides the conceptual foundation for activity productivity analysis.

EXHIBIT 15-6 Activity Productivity Model



An Illustrative Example

To illustrate activity productivity analysis, we will focus on a single activity. Suppose that the activity is purchasing. The output of purchasing is a purchase order, and the number of purchase orders is a possible output measure. For simplicity, assume that labor and materials (forms, postage stamps, and envelopes) are the only resources consumed by the activity. At the end of 2006, the purchasing activity had been streamlined by redesigning the purchase order, reducing the number of suppliers, and reducing the number of distinct parts that needed to be ordered. Activity data for purchasing for 2006 and 2007 follow. The 2007 data reflect the effect of the activity improvements.

	2006	2007
Number of purchase orders	200,000	240,000
Materials used (lbs.)	50,000	50,000
Labor used (number of workers)	40	30
Cost per pound of material	$1	$0.80
Cost (salary) per worker	$30,000	$33,000

Exhibit 15-7 presents the profile and profit-linked analyses for the purchasing activity. Profile analysis reveals that productivity improved for both partial input measures. The value of these productivity improvements is $602,000—with the majority of the value being created by an increase in purchasing labor productivity. Thus, changes in activity productivity can be assessed or predicted using the same methodology available for assessing manufacturing productivity.

EXHIBIT 15-7 **Activity Productivity Analysis Illustrated**

Profile Analysis

	2006	2007
Materials	4	4.8
Labor	5,000	8,000

Profit-Linked Productivity Measurement

Input	(1) PQ*	(2) PQ × P	(3) AQ	(4) AQ × P	(2) − (4) (PQ × P) − AQ × P)
Materials	60,000	$ 48,000	50,000	$ 40,000	$ 8,000
Labor	48	1,584,000	30	990,000	594,000
		$1,632,000		$1,030,000	$602,000

*Materials: 240,000/4; Labor: 240,000/5,000.

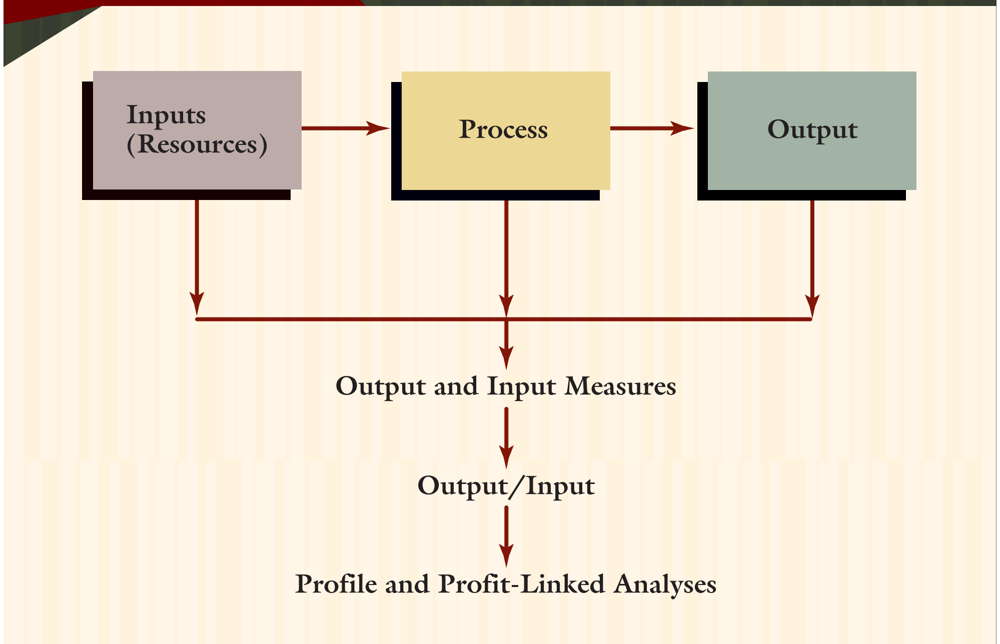
Limitations of Activity Productivity Analysis

Activities within an organization can be classified as value-added and non-value-added. Value-added activities that are performed inefficiently cause non-value-added costs and can be improved. Thus, activity productivity analysis can be a useful tool for predicting and monitoring efficiency improvements for the value-added category of activities. Non-value-added activities are unnecessary activities, and firms should strive to eliminate these activities. Increasing the efficiency of an unnecessary activity does not make a lot of sense. In fact, it is possible that productivity ratios taken over time might signal a decrease in non-value-added activity productivity, and yet the underlying change may very well be consistent with the objective of reducing and eliminating the non-value-added activity. For example, suppose that the output of materials handling is measured by number of moves and that labor is the only significant activity input. Suppose that efforts are made to reduce the user demands for materials handling. In 2006, 50,000 moves were made using 10 workers, producing a productivity ratio of 5,000 moves per worker. In 2007, the demand for materials movement decreased to 22,000 moves and five workers because of the improvement efforts, producing a productivity ratio of 4,400 moves per worker. Comparing ratios indicates that activity productivity has decreased. Yet, the actions taken have produced results that are fully consistent with reducing and eliminating the materials handling activity. Thus, it seems reasonable to exercise caution in the use of interpretation of activity productivity analysis for non-value-added activities. One possibility is to limit non-value-added productivity analysis to changes in actual activity costs, where decreases are viewed as favorable and increases as unfavorable. A third possibility is to consider non-value-added productivity analysis only within the context of process productivity changes.

Process Productivity Analysis

Processes are defined by activities with a common goal. The common goal is usually defined as the output produced by the process. A process's output consumes the activities of the process, which, in turn, consume resources (labor, materials, etc.). This suggests that process productivity changes are defined by two components: (1) changes in the efficiency of activities consuming resources and (2) changes in the efficiency of the process output's consumption of activities. The process for measuring the resource efficiency component has already been discussed and can be reviewed by examining Exhibit 15-6. The second component treats *activity outputs* as inputs and evaluates productivity by relating activities to the output produced by the process. A partial measure of productivity is computed for each activity that belongs to the process. These partial measures are used for profile and profit-linked analyses. Exhibit 15-8 summarizes and illustrates the productivity model for the second process component (activity output efficiency). Notice that the input for the productivity calculation of this process component is simply the activity output measure, and the output is the product of the process. The *cost* per unit of input (i.e., activity output in this case) is the *activity rate derived from* PQ *and current prices.*[3] Process output must also be defined and measured. Each organization has a variety of processes such as product development, procurement, manufacturing, sales, order fulfillment, and customer service. Each process has one or more outputs. Manufacturing, for example, may produce two or more products. In this case, products are the output of manufacturing. Where a process has multiple output measures,

EXHIBIT 15-8 Process Productivity: Activity Output Efficiency



3. The cost assigned to an activity to calculate the activity rate is based on *Q* and current input prices. A rate based on *AQ* and current prices will not capture the savings from reducing demand for activity output.

productivity analysis is carried out for each type of output. Inputs are measured by computing the demands that each product (output) makes on each activity.

Process Productivity Model

Total process productivity change is simply the sum of the two components: Resource efficiency + Activity output efficiency. This approach has the advantage of allowing both value-added and non-value-added activities to be considered simultaneously. The sum of the two components should reveal the correct effect of changes in both types of activities. Also, it is possible to evaluate the effect on process productivity resulting from trade-offs among activities that make up the process. Process improvement or innovation means finding new ways—often, radically new ways—of producing the process's output. This is accomplished by using activity selection, activity reduction, activity elimination, and activity sharing. The effect is to change the mix and quantity of activities that define the process. Process productivity analysis offers a way to measure the proposed and actual *economic* effects of process improvement or innovation.

An Illustrative Example

Process productivity analysis can be applied to any process within the firm: product development, sales, order fulfillment, customer service, manufacturing, etc. The sales process, for example, is defined by activities such as locating prospects, qualifying prospects, making sales calls (approaching the customer), preparing sales presentations, handling objections, closing the sale, and following up. The output of the sales process is a sales order. Consider the sales process of Carthage Company and two of its activities: making sales calls and handling objections. Of the two activities, making sales calls is value-added, and handling objections is non-value-added. At the end of 2006, Carthage initiated some process changes that were designed to improve sales efficiency. Carthage initiated actions to improve the customer locating and qualifying activities, believing that this would improve the efficiency of sales calls and reduce the number of objections from potential customers. Sales personnel were also provided more training to improve their sales presentations. This was expected to reduce the number of objections as well. Information relating to the sales process, its output, and the two activities is presented in Exhibit 15-9

EXHIBIT 15-9 Productivity Data: Sales Process, Carthage Company

	2006	2007
Number of sales orders	20,000	25,000
Activity data:		
Making sales calls		
Number of calls (output)	50,000	40,000
Labor used (hrs.)	100,000	80,000
Materials used (lbs.)	200,000	200,000
Cost per pound of material	$6	$5
Labor cost (per hour)	$30	$30
Activity rate	$84	$80
Handling objections		
Number of objections handled (output)	25,000	10,000
Labor used (hrs.)	30,000	15,000
Materials used (number of samples)	25,000	5,000
Cost per sample	$40	$40
Labor cost per hour	$30	$30
Activity rate	$76	$76

for the years 2006 and 2007. For simplicity, the analysis is confined to only two activities.

Resource inputs, their prices, and activity output are needed for analyzing resource efficiency. On the other hand, activity output, activity rates, and process output are needed for analyzing activity output efficiency. Exhibit 15-9 provides the needed data for both analyses. Using data from Exhibit 15-9, Exhibit 15-10 provides the productivity analysis for the resource efficiency component, and Exhibit 15-11, Panel A, (on the following page) provides the productivity analysis for the activity output efficiency component. The total process productivity effect (the sum of the two components) is shown in Panel B of Exhibit 15-11.

Panel B of Exhibit 15-11 shows that overall process productivity increased dramatically, causing an increase in profits totaling $3,326,440. This increase is mostly

EXHIBIT 15-10 Resource Efficiency Component (Activity Productivity)

A. Making Sales Calls

Profile Analysis

	2006	2007
Labor	0.50	0.50
Materials	0.25	0.20

Profit-Linked Productivity Measurement

Input	(1) *PQ**	(2) *PQ* × *P*	(3) *AQ*	(4) *AQ* × *P*	(2) − (4) (*PQ* × *P*) − (*AQ* × *P*)
Labor	80,000	$2,400,000	80,000	$2,400,000	$ 0
Materials	160,000	800,000	200,000	1,000,000	(200,000)
		$3,200,000		$3,400,000	$(200,000)

*Labor: 40,000/0.50; Materials: 40,000/0.25.

B. Handling Objections

Profile Analysis

	2006	2007
Labor	0.83	0.67
Materials	1.00	2.00

Profit-Linked Productivity Measurement

Input	(1) *PQ**	(2) *PQ* × *P*	(3) *AQ*	(4) *AQ* × *P*	(2) − (4) (*PQ* × *P*) − (*AQ* × *P*)
Labor	12,048	$361,440	15,000	$450,000	$ (88,560)
Materials	10,000	400,000	5,000	200,000	200,000
		$761,440		$650,000	$111,440

*Labor: 10,000/0.83; Materials: 10,000/1.0.

EXHIBIT 15-11 Activity Output Efficiency and Total Process Productivity

A. Activity Output Efficiency

	Profile Analysis 2006	Profile Analysis 2007
Making sales calls[a]	0.400	0.625
Handling objections[b]	0.800	2.500

[a]20,000/50,000; 25,000/40,000.
[b]20,000/25,000; 25,000/10,000.

Profit-Linked Productivity Measurement

Input	(1) *PQ**	(2) $PQ \times P$	(3) *AQ*	(4) $AQ \times P$	(2) − (4) $(PQ \times P) - (AQ \times P)$
Calls	62,500	$5,000,000	40,000	$3,200,000	$1,800,000
Objections	31,250	2,375,000	10,000	760,000	1,615,000
		$7,375,000		$3,960,000	$3,415,000

*25,000/0.4; 25,000/0.8.
Note: P is the activity rate for 2007.

B. Total Process Productivity

		Source
Resource usage component:		
Making calls	$ (200,000)	Exhibit 15-10
Handling objections	111,440	Exhibit 15-10
Activity output component	3,415,000	Panel A, Exhibit 15-11
Total process productivity change	$3,326,440	

attributable to the fact that demand has dropped sharply for activity output. For example, profile analysis reveals that the orders per complaint have increased from 0.800 to 2.500 (Exhibit 15-11, Panel A), a significant increase in productivity. Similarly, the orders per sales call have increased from 0.400 to 0.625. However, of the two activities, only one contributed to increasing process efficiency by increasing activity resource efficiency. In fact, the net activity resource efficiency was negative (see Exhibit 15-10).

Service Productivity

The process productivity model is easily adapted to service organizations. All organizations have processes. These processes can be identified, activities and output can be defined, and productivity measurement can occur. **IBM Credit**, for example, is a service organization that offers financing for the computers, software, and services that **IBM Corporation** sells.[4] Within IBM Credit, one of the major processes is its quote preparation process. The quote preparation process is defined by the following activities: logging the request, assessing

4. A more complete discussion of the IBM Credit example can be found in the following two sources: Michael Hammer and James Champy, *Reengineering the Corporation* (New York: HarperBusiness, 1993): 36–39; and Thomas H. Davenport, *Process Innovation* (Boston: Harvard Business School Press, 1993): 2, 32–33, and 158.

creditworthiness, modifying loan covenants, pricing, and preparing and delivering a quote letter. Since the activities were located in separate departments, the process also included a movement activity—an activity that required the transfer of each activity's output from one location to another. Essentially, the customer's credit application was transferred from department to department, a transfer occurring only after a particular department had finished its activity (e.g., the credit department transfers the application to the business practices department after it has assessed creditworthiness). The process's output can be defined as financing approval and can be measured by the number of quotes. Before any effort at process improvement, it took about six days to prepare a quote. IBM Credit redesigned the process by eliminating the non-value-added movement activity. It accomplished this by having one person process the entire application from beginning to end. This had two outcomes. First, the time required to process an application was reduced from six days to a few hours. Second, the labor productivity ratio was dramatically improved. The number of workers remained about the same, and yet the number of quotes being processed increased 100 times. This means, for example, that if the partial labor productivity ratio was 10 before the improvement, it is now 1,000!

Activities and Process Productivity Measurement

Since activity output is a process input, reducing non-value-added activities should normally show up as a process productivity improvement. Why? Reducing non-value-added activities means finding ways to produce the same or higher process output with less non-value-added activity output. Thus, the output/input ratios will show an increase in process productivity (through the activity output efficiency component). The objective is to produce process output without any non-value-added activity input. Reducing and eliminating non-value-added activities means improving the technical efficiency of processes. Therefore, it is important to identify all non-value-added activity inputs for a process. This means that we must exercise caution in identifying and defining the activities that are used by the process being evaluated.

Quality and Productivity

Improving quality may improve productivity, and vice versa. For example, consider rework, an internal failure activity. If rework is reduced by producing fewer defective units, then less labor and fewer materials are used to produce the same output. Reducing the number of defective units improves quality; reducing the amount of inputs used improves productivity.

Since most quality improvements reduce the amount of resources used to produce and sell an organization's output, most quality improvements will improve productivity. Thus, quality improvements will generally be reflected in productivity measures. However, there are other ways to improve productivity other than through quality improvement. A firm may produce a good with little or no defects but still have an inefficient process.

For example, consider a good that passes through two 5-minute processes. (Assume the good is produced free of defects.) One unit, then, requires 10 minutes to pass through both processes. Currently, units are produced in batches of 1,200. Process 1 produces 1,200 units. Then, the batch is conveyed by forklift to another location, where the units pass through Process 2. Thus, for each process, a total of 6,000 minutes, or 100 hours, is needed to produce a batch. The 1,200 finished units, then, require a total of 200 hours (100 hours for each process) plus conveyance time (assume that to be 15 minutes).

By redesigning the manufacturing process, efficiency can be improved. Suppose that the second process is located close enough to the first process so that as soon as a unit is completed by the first process, it is passed to the second process. In this way, the first and second processes can be working at the same time. The second process no longer has to wait for the production of 1,200 units plus conveyance time before it can begin operation. The total time to produce 1,200 units now is 6,000 minutes plus the waiting time for the first unit (five minutes). Thus, production of 1,200 units has been reduced from 200 hours and 15 minutes to 100 hours and five minutes. More output can be produced with fewer inputs. The moving and waiting activities are non-value-added inputs that have been virtually eliminated, thereby improving process productivity.

SUMMARY

Productivity deals with how efficiently inputs are used to produce the output. Partial measures of productivity evaluate the efficient use of single inputs. Total measures of productivity assess efficiency for all inputs. Profit-linked productivity effects are calculated by using the linkage rule. Essentially, the profit effect is computed by taking the difference between the cost of the inputs that would have been used without any productivity change and the cost of the actual inputs used. Because of the possibility of input trade-offs, it is essential to value productivity changes. Only in this way can the effect of productivity changes be properly assessed. Productivity analysis can be used to assess activity performance. Two approaches can be used to assess activity efficiency: activity productivity analysis and process productivity analysis. Activity productivity analysis is primarily used for assessing changes in the efficiency of value-added activities. Process productivity analysis can be used to assess productivity of processes and of both value- and non-value-added activities that define the process.

REVIEW PROBLEM AND SOLUTION

PRODUCTIVITY

At the end of 2006, Homer Company implemented a new labor process and redesigned its product with the expectation that input usage efficiency would increase. Now, at the end of 2007, the president of the company wants an assessment of the changes in the company's productivity. The data needed for the assessment are as follows:

	2006	*2007*
Output	10,000	12,000
Output prices	$20	$20
Materials (lbs.)	8,000	8,400
Materials unit price	$6	$8
Labor (hrs.)	5,000	4,800
Labor rate per hour	$10	$10
Power (kwh)	2,000	3,000
Price per kwh	$2	$3

Required:

1. Compute the partial operational measures for each input for both 2006 and 2007. What can be said about productivity improvement?
2. Prepare a partial income statement for each year, and calculate the total change in profits.
3. Calculate the profit-linked productivity measure for 2007. What can be said about the productivity program?
4. Calculate the price-recovery component. What does this tell you?

SOLUTION

1. Partial measures:

	2006	2007
Materials	10,000/8,000 = 1.25	12,000/8,400 = 1.43
Labor	10,000/5,000 = 2.00	12,000/4,800 = 2.50
Power	10,000/2,000 = 5.00	12,000/3,000 = 4.00

Profile analysis indicates that productive efficiency has increased for materials and labor and decreased for power. The outcome is mixed, and no statement about overall productivity improvement can be made without valuing the trade-off.

2. Income statements:

	2006	2007
Sales	\$200,000	\$240,000
Cost of inputs	102,000	124,200
Gross profit	\$ 98,000	\$115,800

Total change in profits: \$115,800 − \$98,000 = \$17,800 increase

3. Profit-linked measurement:

Input	(1) PQ*	(2) PQ × P	(3) AQ	(4) AQ × P	(2) − (4) (PQ × P) − (AQ × P)
Materials	9,600	\$ 76,800	8,400	\$ 67,200	\$ 9,600
Labor	6,000	60,000	4,800	48,000	12,000
Power	2,400	7,200	3,000	9,000	(1,800)
		\$144,000		\$124,200	\$19,800

*Materials: 12,000/1.25; Labor: 12,000/2; Power: 12,000/5.

The value of the increases in efficiency for materials and labor more than offsets the increased usage of power. Thus, the productivity improvement program should be labeled successful.

4. Price recovery:

Price-recovery component = Total profit change − Profit-linked productivity change

Price-recovery component = \$17,800 − \$19,800
= (\$2,000)

This says that without the productivity improvement, profits would have declined by \$2,000. The \$40,000 increase in revenues would not have offset the increase in the cost of inputs. From the solution to Requirement 3, the cost of inputs without a productivity increase would have been \$144,000 (column 2). The increase in the input cost without productivity would have been \$144,000 − \$102,000 = \$42,000. This is \$2,000 more than the increase in revenues. Only because of the productivity increase did the firm show an increase in profitability.

KEY TERMS

QUESTIONS FOR WRITING AND DISCUSSION

1. Define *total productive efficiency*.
2. Explain the difference between technical and allocative efficiency.
3. What is productivity measurement?
4. Explain the difference between partial and total measures of productivity.
5. What is an operational productivity measure? A financial measure?
6. Discuss the advantages and disadvantages of partial measures of productivity.
7. What is the purpose of a base period?
8. What is profile measurement and analysis? What are the limitations of this approach?
9. What is profit-linked productivity measurement and analysis?
10. Explain why profit-linked productivity measurement is important.
11. What is the price-recovery component?
12. What is activity productivity analysis, and what are its limitations?
13. What is process productivity analysis?
14. Can productivity improvements be achieved without improving quality? Explain.
15. Why is it important for managers to be concerned with both productivity and quality?

EXERCISES

15-1 Technical and Price Efficiency

LO1 Listed below are several possible input combinations for producing 5,000 units of a pocket PC. Two of the input combinations are technically efficient.

	Materials	*Labor*	*Energy*
Unit input prices	$150	$125	$50
Input combinations:			
A	250	480	1,800
B	275	450	1,350
C	230	475	1,425
D	375	500	1,500

Required:

1. Identify the technically efficient input combinations. Explain your choices.
2. Which of the two technically efficient input combinations should be used? Explain.

15-2 Productivity Measurement, Technical and Allocative Efficiency, Partial Measures

LO1, LO2

Gambiano Company produces hand-crafted pottery that uses two inputs, materials and labor. During the past quarter, 20,000 units were produced, requiring 80,000 pounds of material and 40,000 hours of labor. An engineering efficiency study commissioned by the local university revealed that Gambiano can produce the same 20,000 units of output using either of the following two combinations of inputs:

	Materials	*Labor*
Combinations:		
F1	60,000	30,000
F2	66,000	28,000

The cost of materials is $8 per pound; the cost of labor is $12 per hour.

Required:

1. Compute the output-input ratio for each input of Combination F1. Does this represent a productivity improvement over the current use of inputs? What is the total dollar value of the improvement? Classify this as a technical or an allocative efficiency improvement.
2. Compute the output-input ratio for each input of Combination F2. Does this represent a productivity improvement over the current use of inputs? Now, compare these ratios to those of Combination F1. What has happened?
3. Compute the cost of producing 20,000 units of output using Combination F1. Compare this cost to the cost using Combination F2. Does moving from Combination F1 to Combination F2 represent a productivity improvement? Explain.

15-3 Interperiod Measurement of Productivity, Profiles

LO2

Helena Company needs to increase its profits and so has embarked on a program to increase its overall productivity. After one year of operation, Kent Olson, manager of the Columbus plant, reported the following results for the base period and its most recent year of operations:

	2006	*2007*
Output	307,200	360,000
Power (quantity used)	38,400	18,000
Materials (quantity used)	76,800	81,000

Required:

Compute the productivity profiles for each year. Did productivity improve? Explain.

15-4 Interperiod Measurement of Productivity, Profit-Linked Measurement

LO3

Spreadsheet

Refer to **Exercise 15-3**. Suppose the following input prices are provided for each year:

	2006	*2007*
Unit price (power)	$ 2	$ 3
Unit price (materials)	16	15
Unit selling price	6	8

Required:

1. Compute the profit-linked productivity measure. By how much did profits increase due to productivity?
2. Calculate the price-recovery component for 2007. Explain its meaning.

15-5 ACTIVITY PRODUCTIVITY, NON-VALUE-ADDED ACTIVITY

LO4

Spreadsheet

Rework, a non-value-added activity, is part of Jorgensen Manufacturing's assembly process. Testing often revealed that one or more components (almost always sourced from outside suppliers) had failed. At the end of 2006, Jorgensen initiated efforts designed to buy higher-quality components. Consequently, the demand for the rework activity was expected to decrease. The following data pertain to the reordering activity for the years 2006 and 2007:

	2006	*2007*
Units assembled	300,000	300,000
Units reworked	7,500	3,600
Rework components (number)	15,000	7,200
Rework labor hours	12,000	6,000
Labor cost per hour	$12	$15
Cost per component	$20	$20
Activity rate	$59	$64

Required:

1. Identify the output measure for the rework activity.
2. Calculate the productivity profile and the profit-linked measure for the rework activity. Is reducing the demand for a non-value-added activity the correct decision? Does this benefit show up in the productivity measure? Explain.

15-6 PROCESS PRODUCTIVITY, NON-VALUE-ADDED ACTIVITY

LO4

Refer to **Exercise 15-5**.

Required:

1. Identify the output measure for the assembly process. Calculate the productivity profile and profit-linked measure of the assembly process where the output of the rework activity is viewed as a process input. Does this indicate anything about the value of reducing demand for a non-value-added activity?
2. Calculate the total process productivity change. What does this indicate about the actions taken regarding the non-value-added activity?

15-7 PRODUCTIVITY MEASUREMENT: TRADE-OFFS, PROFILE AND PROFIT-LINKED ANALYSES

LO2, LO3

Spreadsheet

Bradshaw Company has recently installed a computer-aided manufacturing system. The decision to automate was made so that material waste could be reduced. Better quality and a reduction of labor inputs were also expected. After one year of operation, management wants to see if the expected productivity improvements have materialized. The president is particularly interested in knowing whether the trade-off between capital, labor, and materials was favorable. Data concerning output, labor, materials, and capital are provided for the year before implementation and the year after.

	Year Before	*Year After*
Output	100,000	120,000
Input quantities:		
Materials (lbs.)	25,000	20,000
Labor (hours)	5,000	2,000
Capital (dollars)	$10,000	$300,000
Input prices:		
Materials	$5	$5
Labor	$10	$10
Capital	10%	10%

Required:

1. Prepare a productivity profile for each year. Evaluate the productivity changes.
2. Calculate the change in profits attributable to the change in productivity of the three inputs. Assuming that these are the only three inputs, evaluate the decision to automate.

15-8 Prospective Productivity Measurement, Technical and Allocative Efficiency, Profile and Profit-Linked Analyses

LO1, LO2, LO3 The manager of Blakely Company was reviewing two competing projects for the molding department. The projects represented different methods of preparing the molds for one of the company's more popular product lines. One project changed the way molds were poured and promised a savings in material usage. The second project redesigned the process so that labor was used more efficiently. The fiscal year was coming to a close, and the manager wanted to make a decision concerning the proposed process changes so that they could be used, if beneficial, during the coming year. The process changes would affect the department's input usage. For the year just ended, the accounting department provided the following information about the inputs used to produce 100,000 units of output:

	Quantity	*Unit Prices*
Materials	200,000 lbs.	$ 8
Labor	80,000 hrs.	10
Energy	40,000 kwh	2

Each project offers a different process design from the one currently being used. Neither project would cost anything to implement. Expected input usage for producing 120,000 units (the expected output for the coming year) for each project is as follows:

	Project I	*Project II*
Materials	200,000 lbs.	220,000 lbs.
Labor	80,000 hrs.	60,000 hrs.
Energy	40,000 kwh	40,000 kwh

Input prices are expected to remain the same for the coming year.

Required:

1. Prepare a productivity profile analysis for the most recently completed year and each project. Does either proposal improve technical efficiency? Explain. Can you make a recommendation about either project using only the physical measures?

2. Calculate the profit-linked productivity measure for each proposal. Which proposal offers the best outcome for the company? How does this relate to the concept of price efficiency? Explain.

15-9 Basics of Productivity Measurement

LO1, LO2, LO3

Spreadsheet

Holbrook Company gathered the following data for the past two years:

	Base Year	*Current Year*
Output	900,000	1,080,000
Output prices	$15	$15
Input quantities:		
Materials (lbs.)	1,200,000	720,000
Labor (hrs.)	300,000	540,000
Input prices:		
Materials	$5	$6
Labor	$8	$8

Required:

1. Prepare a productivity profile for each year.
2. Prepare partial income statements for each year. Calculate the total change in income.
3. Calculate the change in profits attributable to productivity changes.
4. Calculate the price-recovery component. Explain its meaning.

15-10 Activity Productivity

LO3, LO4

In an effort to become more competitive, Hardy Company has embarked on a program to reduce and eliminate its non-value-added activities and to improve the efficiency of its value-added activities. The activity of paying bills has been classified as value-added and in need of improvement. The major inputs for the activity are clerks, personal computers (PCs), and supplies. Activity output is defined as "paid bills" and is measured by the number of checks issued. The materials handling activity, on the other hand, is classified as a non-value-added activity and is targeted for reduction and possible elimination (at least as a significant activity). The major inputs for materials movement (the output) are labor, forklifts, and supplies. Over a 2-year period, Hardy has made some changes in the way each activity is performed. For example, Hardy has redesigned its plant layout to reduce the demand for materials movement. Process innovation also dramatically changed the way that bills were paid. Data are provided for the two activities for a base year and the most recent year completed. The year just completed was the second year of Hardy's improvement program.

Activity	*Base Year*	*Most Recent Year*
Paying bills:		
Output	300,000	320,000
Inputs:		
Clerks (no.)	15	5
PCs (no.)	15	5
Supplies (lbs.)	150,000	40,000
Moving materials:		
Output	20,000	5,000
Inputs:		
Labor (hrs.)	10,000	3,000
Forklifts (no.)	5	2
Supplies (lbs.)	4,000	2,000

Required:

1. Prepare productivity profiles for both activities. Comment on the usefulness of these profiles for assessing improvement in activity performance.
2. Given the following most recent year's input prices for the paying bills activity, calculate the activity's profit-linked measure:

Clerks	$25,000 per person
PCs	$5,000 per system
Supplies	$1 per pound

PROBLEMS

15-11 Process and Activity Productivity

LO3, LO4

In 2006, Maravilla Auto's Motor Division hired a consulting firm to help identify and define the processes used within the division. Megan Dorr, the divisional manager, also asked the consulting firm to make recommendations concerning the reengineering of the processes to improve overall efficiency. Six major processes were defined. The consulting firm prepared six documents—one for each process. The following memo from Bill Gray, the consulting partner in charge, summarizes the major points for the procurement process. (The procurement process is one of the six major processes.)

MEMO

To: Megan Dorr, Divisional Manager
From: Bill Gray, Partner, Jackson Consulting
Subject: Procurement Process
Date: April 15, 2006

The procurement process consists of three major activities: purchasing, receiving, and paying bills. Currently, the procurement process begins with the purchasing department sending a purchase order to a supplier. When the order is received from the supplier, the receiving department fills out a receiving document and sends it to accounts payable. Accounts payable also receives an invoice from the supplier (through the mail). Clerks in accounts payable compare the three documents and issue a check if all three match. At times, there are discrepancies, and accounts payable clerks are responsible for resolving these discrepancies before payment is made. Resolution of discrepancies may take weeks and often consumes considerable clerical resources. This resolution activity is non-value-added, and a process redesign can eliminate it and save significant resources. We estimate that about 80 percent of clerical time is spent dealing with these discrepancies.

We recommend that payment authorization be changed from accounts payable to receiving. This change requires the acquisition of several terminals that will be used to access purchase information in the company's database. It also requires new software that will permit the following: (1) When the goods arrive from a supplier, the receiving clerk will check to see if the shipment is supported with an outstanding purchase order; (2) If there is a corresponding purchase order indicating the type and quantity of goods received, then the clerk can signal acceptance using the keyboard, and the computer will issue a check at the appropriate time for payment; (3) If there is no supporting documentation or if the type and quantity of goods received differ from the purchase order, then the goods are simply shipped back to the supplier.

After reviewing the memo, Megan Dorr set in motion the necessary actions to implement the consultant's recommendations. The terminals were purchased, and the required supporting software was developed. Since suppliers often shipped partial orders, the software was modified to allow for this possibility. Now, two years later, Megan wants an analysis of the productivity gains or losses that have resulted from the process changes that have been implemented. Output for the procurement process is defined as the number of units purchased and paid for (of all types). Data for 2006 and 2008 for the procurement process and its activities are as follows:

Process Output, Activity Demands, and Input Prices

	2006	*2008*
Units purchased and paid for	3,000,000	3,600,000
Purchase orders	100,000	120,000
Receiving orders	150,000	180,000
Bills paid	150,000	180,000
Input prices:		
Supplies (per lb.)	$1.80	$2
Clerks (salary per person)	$30,000	$40,000
Capital (interest rate)	10%	10%

Activity Information

	Purchasing	*Receiving*	*Paying Bills*
2006:			
Supplies (lbs.)	50,000	40,000	75,000
Clerks (no.)	25	50	100
Capital (dollars)	$1,000,000	$800,000	$500,000
2008:			
Supplies (lbs.)	60,000	30,000	5,000
Clerks (no.)	25	50	10
Capital (dollars)	$1,200,000	$3,000,000	$1,000,000
Activity rates	$12.00	$14.40	$28.00

Required:

1. Compute the profit-linked measure of productivity for each of the three activities. This is the first component of procurement process productivity analysis.
2. Calculate the profit-linked measure for the activity output efficiency component of process productivity analysis.
3. Now, add the two profit-linked measures of Requirements 1 and 2. Explain the meaning of this measure. Was the company successful in increasing the productivity of the procurement process?

15-12 Productivity and Quality, Prospective Analysis

LO2, LO3 Walnut Company is considering the acquisition of a computerized manufacturing system. The new system has a built-in quality function that increases the control over product specifications. An alarm sounds whenever the product falls outside the programmed specifications. An operator can then make some adjustments on the spot to restore the desired product quality. The system is expected to decrease the number of units scrapped because of poor quality. The system is also expected to decrease the amount of labor inputs needed. The production manager is pushing for the acquisition because he believes that productivity will be greatly enhanced—particularly when it comes to labor and material inputs. Output and input data follow. The data for the computerized system are projections.

	Current System	*Computerized System*
Output (units)	20,000	20,000
Output selling price	$40	$40
Input quantities:		
Materials	80,000	70,000
Labor	40,000	30,000
Capital (dollars)	$40,000	$200,000
Energy	20,000	50,000
Input prices:		
Materials	$4.00	$4.00
Labor	$9.00	$9.00
Capital (percent)	10.00%	10.00%
Energy	$2.00	$2.50

Required:

1. Compute the partial operational ratios for materials and labor under each alternative. Is the production manager right in thinking that materials and labor productivity increase with the automated system?
2. Compute the productivity profiles for each system. Does the computerized system improve productivity?
3. Determine the amount by which profits will change if the computerized system is adopted. Are the trade-offs among the inputs favorable? Comment on the system's ability to improve productivity.

15-13 Productivity Measurement, Basics

LO3 Fowler Company produces handcrafted leather purses. Virtually all of the manufacturing cost consists of materials and labor. Over the past several years, profits have been declining because the cost of the two major inputs has been increasing. Wilma Fowler, the president of the company, has indicated that the price of the purses cannot be increased; thus, the only way to improve or at least stabilize profits is to increase overall productivity. At the beginning of 2007, Wilma implemented a new cutting and assembly process that promised less materials waste and a faster production time. At the end of 2007, Wilma wants to know how much profits have changed from the prior year because of the new process. In order to provide this information to Wilma, the controller of the company gathered the following data:

	2006	*2007*
Unit selling price	$16	$16
Purses produced and sold	18,000	24,000
Materials used	36,000	40,000
Labor used	9,000	10,000
Unit price of materials	$4	$4.50
Unit price of labor	$9	$10

Required:

1. Compute the productivity profile for each year. Comment on the effectiveness of the new production process.
2. Compute the increase in profits attributable to increased productivity.
3. Calculate the price-recovery component, and comment on its meaning.

15-14 Productivity Measurement, Technical and Price Efficiency

LO1, LO3 In 2006, Fleming Chemicals used the following input combination to produce 55,000 gallons of an industrial solvent:

Materials	33,000 lbs.
Labor	66,000 hrs.

In 2007, Fleming again planned to produce 55,000 gallons of solvent and was considering two different changes in process, both of which would be able to produce the desired output. The following input combinations are associated with each process change:

	Change I	*Change II*
Materials	38,500 lbs.	27,500 lbs.
Labor	44,000 hrs.	55,000 hrs.

The following combination is optimal for an output of 55,000 units. However, this optimal input combination is unknown to Fleming.

Materials	22,000 lbs.
Labor	44,000 hrs.

The cost of materials is $60 per pound, and the cost of labor is $15 per hour. These input prices hold for 2006 and 2007.

Required:

1. Compute the productivity profiles for each of the following:
   a. The actual inputs used in 2006
   b. The inputs for each proposed 2007 process change
   c. The optimal input combination

   Will productivity increase in 2007, regardless of which change is used? Which process change would you recommend based on the prospective productivity profiles?
2. Compute the cost of 2006's productive inefficiency relative to the optimal input combination. Repeat for 2007 proposed input changes. Will productivity improve from 2006 to 2007 for each process change? If so, by how much? Explain. Include in your explanation a discussion of changes in technical and allocative efficiency.
3. Since the optimal input combination is not known by Fleming, suggest a way to measure productivity improvement. Use this method to measure the productivity improvement achieved from 2006 to 2007. How does this measure compare with the productivity improvement measure computed using the optimal input combination?

15-15 Process Productivity Measurement: Second Component (Activity Output Efficiency)

LO3, LO4 Wright Manufacturing has recently studied its order-filling process and initiated some changes that were expected to improve its efficiency. The changes involved such things as redesign of the plant layout, redesign of documents, keyboard training, and improvement in automated system controls. The changes were expected to improve process productivity over a period of several years. The order-filling process is defined by the following three activities: handling goods, entering data, and detecting errors. The output measure for the process is the number of orders filled. The handling activity's output (movement of goods) is measured by yards traveled; the entering data activity's output is measured by data entry time; and the output of detecting errors is measured by the number of documents inspected (compares document data with input record). Data for the year prior to the changes and for two years following the changes are as follows:

	2005	*2006*	*2007*
Output measures:			
Number of orders filled	150,000	165,000	200,000
Yards traveled	1,500,000	825,000	400,000
Data entry time (hrs.)	50,000	41,250	40,000
Documents inspected	150,000	82,500	50,000
Activity rates:			
Handling goods (per yard)	$1	$1	$1.25
Entering data (per hour)	$7	$7	$8.00
Detecting errors (per document)	$2	$2	$2.00

Required:

1. Calculate the productivity profiles for all three years. What can you say about productivity improvement for this process? Comment on the value of multiyear comparisons of productivity profiles.
2. Calculate the profit-linked measures for 2006 and 2007, using 2005 as the base year for 2006 and using 2006 as the base year for 2007. Is there any value to changing base years? Explain.

15-16 Productivity Measurement, Price Recovery

LO2, LO3 The Small Motors Division of Polson Company has recently engaged in a vigorous effort to reduce manufacturing costs by increasing productivity (through process innovation). Over the past several years, price competition has become very intense, and recent events called for another significant price decrease. Without the price decrease, the marketing manager estimates that the division's market share would drop by 30 percent. The marketing manager estimates that a price decrease of $5.00 per unit is needed in 2007 to maintain market share. (Since the market is expanding, maintaining the market share means an increase in units sold.) The small motors sold for $70 each in 2006. However, the divisional manager indicated that the revenues lost by the price decrease must be offset by increased cost efficiency. Any further deterioration in profits could threaten the division's continued existence. Thus, in 2007, processes were reengineered in an effort to improve productivity. At the end of 2007, the divisional manager wanted an assessment of the effects of the process changes. To assess the changes in productive efficiency, the following data were gathered:

	2006	*2007*
Output	50,000	60,000
Input quantities:		
Materials	50,000	40,000
Labor	200,000	100,000
Capital	$2,000,000	$5,000,000
Energy	50,000	150,000
Input prices:		
Materials	$8	$10
Labor	$10	$12
Capital	15%	10%
Energy	$2	$2

Required:

1. Calculate the productivity profile for each year. Can you say that productivity has improved? Explain.
2. Calculate the total profit change from 2006 to 2007. How much of this change is attributable to productivity? To price recovery?
3. Calculate the cost per unit for 2006 and 2007. Was the division able to decrease its per-unit cost by at least $5.00? Comment on the relationship of competitive advantage and productive efficiency.

15-17 Quality and Productivity, Interaction, Use of Operational Measures

LO3 Andy Confer, production-line manager, had arranged a visit with Will Keating, plant manager. He had some questions about the new operational measures that were being used.

ANDY: Will, my questions are more to satisfy my curiosity than anything else. At the beginning of the year, we began some new procedures that require us to work toward increasing our output per pound of material and decreasing our output per labor hour. As instructed, I've been tracking these operational measures for each batch we've produced so far this year. Here's a copy of a trend report for the first five batches of the year. Each batch had 10,000 units in it.

Batches	*Material Usage*	*Ratio*	*Labor Usage*	*Ratio*
1	4,000 lbs.	2.50	2,000 hrs.	5.00
2	3,900	2.56	2,020	4.95
3	3,750	2.67	2,150	4.65
4	3,700	2.70	2,200	4.55
5	3,600	2.78	2,250	4.44

WILL: Andy, this report is very encouraging. The trend is exactly what we hoped for. I'll bet we meet our goal of getting the batch productivity measures. Let's see, those goals were 3.00 units per pound for materials and 4.00 units per hour for labor. Last year's figures were 2.50 for materials and 5.00 for labor. Things are looking good. I guess tying bonuses and raises to improving these productivity stats was a good idea.

ANDY: Maybe so—but I don't understand why you want to make these trade-offs between materials and labor. Materials cost only $5 per pound, and labor costs $10 per hour. It seems as if you're simply increasing the cost of making this product.

WILL: Actually, it may seem that way, but it's not so. There are other factors to consider. You know we've been talking quality improvement. Well, the new procedures you are implementing are producing products that conform to the product's specification. More labor time is needed to achieve this, and as we take more time, we do waste fewer materials. But the real benefit is the reduction in our external failure costs. Every defect in a batch of 10,000 units costs us $1,000—warranty work, lost sales, a customer service department, and so on. If we can reach the material and labor productivity goals, our defects will drop from 20 per batch to five per batch.

Required:

1. Discuss the advantages of using only operational measures of productivity for controlling shop-level activities.
2. Assume that the batch productivity statistics are met by the end of the year. Calculate the change in a batch's profits from the beginning of the year to the end that is attributable to changes in materials and labor productivity.

3. Now, assume that three inputs are to be evaluated: materials, labor, and quality. Quality is measured by the number of defects per batch. Calculate the change in a batch's profits from the beginning of the year to the end that is attributable to changes in productivity of all three inputs. Do you agree that quality is an input? Explain.

15-18 Collaborative Learning Exercise

LO1, LO2, LO3

Kathy Shorts, president of Carbon Industrial Cleaners, had just concluded a meeting with two of her plant managers. She had told each of them that one of their high-volume industrial cleaners was going to have a 50 percent increase in demand—next year—over this year's output (which is expected to be 50,000 barrels). A major foreign source of the material had been shut down because of a trade embargo. It would be years before the source would be available again. The result was twofold. First, the price of the material input was expected to quadruple. Second, many of the less efficient competitors would leave the business, creating more demand and higher output prices—in fact, output prices would double.

In discussing the situation with her plant managers, she reminded them that the automated process now allowed them to increase the productivity of the material. By using more machine hours, evaporation could be decreased significantly. (This was a recent development and would be operational by the beginning of the new fiscal year.) There were, however, only two other feasible settings beyond the current setting. The current usage of inputs for the 50,000-barrel output (current setting) and the input usage for the other two settings follow. The input usage for the remaining two settings is for an output of 75,000 barrels. Inputs are measured in barrels for the material and in machine hours for the equipment.

	Current	*Setting A*	*Setting B*
Input quantities:			
Materials	125,000	75,000	150,000
Equipment	30,000	75,000	37,500

The current prices for this year's inputs are \$3 per barrel for materials and \$12 per machine hour for the equipment. The materials price will change for next year as explained, but the \$12 rate for machine hours will remain the same. The chemical is currently selling for \$20 per barrel. Based on separate productivity analyses, one plant manager chose Setting A and the other chose Setting B.

The manager who chose Setting B justified his decision by noting that it was the only setting that clearly signaled an increase in both partial measures of productivity. The other manager agreed that Setting B was an improvement but that Setting A was even better.

Required:

Work the following requirements before coming to class. Next, form groups of three to four, 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. Prepare productivity profiles for the current year and for the two settings. Which of the two settings signals an increase in productivity for both inputs?
2. Calculate the profits that will be realized under each setting *for the coming year*. Which setting provides the greatest profit increase?
3. Calculate the profit change for each setting attributable to productivity changes. Which setting offers the greatest productivity improvement? By how much? Explain why this happened.

15-19 CYBER RESEARCH CASE

LO2, LO4

Productivity concepts apply to service settings as well as manufacturing. For example, in the health care industry, increasing productivity is a possible means to control rising medical costs. It is also a means of increasing retention.

Required:

1. Go to http://www.findarticles.com, and search for articles on productivity using "Productivity Accounting" as the search phrase (or you can try your own search phrase relating to productivity). Find three articles that relate to productivity of services, where at least one is in the health care industry. Read these articles, and provide a brief summary of their content. Now, answer the following questions:
   a. Did any of the articles mention partial productivity measures?
   b. If so, were the measures operational or financial?
   c. Was there any mention of total productivity measurement? If not, speculate on the reasons why.
   d. What was the purpose of productivity measurement?
2. Now, do a search at the FindArticles site using "Productivity Plus Award." Answer the following questions:
   a. What is the purpose of the award?
   b. Describe two companies that have received the award, and provide a brief summary of why they received it.