CHAPTER 2

Productivity and Process Analysis

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Learning Objectives

In this chapter, we will

- Discuss productivity and productivity measurement
- Learn how to conduct a time study
- Review the DMAIC process
- Introduce process analysis and flowcharting
- List methods of streamlining processes

Productivity

The dilemma of all operations managers is how to increase productivity without sacrificing quality. This is the essential core of operations management—producing as many as possible with as little input as possible. Managers are constantly faced with job cuts yet are expected to produce the same quality product with fewer people to do it. As a result, we are faced with trying to find new and better ways of working, of getting by with less.

Productivity is calculated as the ratio of output to input. What can we produce given the available labor hours or labor dollars, or the available materials or equipment costs? It is the measurement system that provides managers with the information they need to know about how effectively the work is performed.

Every industry has its important set of measurements that act as a scorecard for managers. In the hospital, the administrator is concerned with the ratio of the average length of patient stay to the number of labor hours. A reduction in length of stay, corresponding to an improvement in patient care statistics (however they are measured), with the labor inputs kept equal, could result in an improvement in the hospital's financial health, so these are important productivity measurements for the administrator to analyze (see Table 2.1).

National Productivity and Compensation

Productivity differs across the globe, due to differences in infrastructure, capabilities, and skills. Corporations look at both factors when they select a plant site. When comparing, say, Taiwan with Ireland, they will examine a number of factors, but productivity and wages figure greatly in the decision of where to locate a facility. Tables 2.2 and 2.3 provide 2005 data for productivity and compensation. The manufacturing output uses that country's 1992 productivity to set an index of 100. A number greater than 100 indicates an improvement over the 1992 index. A number of 150, for example, would mean that output had increased by 50%.

Table 2.2 does not show total productivity. What it does show is improvement, with Korea making the greatest improvement since 1992 and Italy the least.

Table 2.1 Productivity Measurements

Type of Company	*Type of Work*	*Measures*
Airline	Reservations	Reservations/hr
	Baggage handling	Bags handled/hr
		Bags lost/bags handled
Hospitals	Patient care	Average length of patient stay
		Revenue/patient
Auto manufacturer	Assembly line	Cars/day
		Cars/labor hr
Call center	Customer service	Calls/labor hr
		Effectiveness/call
Book publisher	Book sales	Sales/printed copies
	Book distribution	Books/shipment
Baseball stadium	Ticket sellers	Tickets/labor hr
	Concessionaires	Revenue/game
Movie theater	Ticket sellers	Tickets/labor hr
	Concessions	Revenue/day
Restaurant	Food sales	Sales/hr
		Sales/labor hr
Retailer	Department store workers	Sales/sq. ft
		Sales/labor hr

Table 2.2 2005 Output per Hour in Manufacturing

Country	*Output*
United States	193.2
United Kingdom	140.0
Canada	139.1
Australia	143.7
Japan	158.2
Korea	300.4
Taiwan	196.5
Belgium	144.9
Denmark	141.6
France	169.2
Germany	154.8
Italy	110.3
Netherlands	161.7
Norway	132.0
Spain	121.5
Sweden	241.9

SOURCE: www.bls.gov

Table 2.3 Index of Hourly Compensation in U.S. Dollars for Manufacturing Workers in 16 Countries (United States = 100)

Country	*Index*
United States	100
Canada	101
Mexico	11
Australia	105
Hong Kong	24
Japan	92
Korea	57
New Zealand	63
Singapore	32
Taiwan	27
Czech Republic	26
France	104
Germany	140
Ireland	96
Switzerland	129
United Kingdom	109

Measurements in Sports

To illustrate how productivity measurements are managed, let us examine a situation in a typical baseball game. Assume that a miracle has happened, and we are in the World Series, and it is the Chicago Cubs versus the New York Yankees. Carlos Zambrano is pitching for the Cubs in the seventh inning, and the batter is the Yankees shortstop, Derek Jeter. Zambrano is a right-handed pitcher, and the game is at night in Chicago. There is one out, a runner is on third base, and the score is Cubs 2, Yankees 0.

The managers of both teams are loaded with statistics for this particular situation. The Cubs manager, Lou Piniella, knows that Zambrano has thrown 95 pitches and that Zambrano is usually effective until he has thrown 110 pitches. He knows Zambrano's record against right-handed batters at night in Wrigley Field, where the game is played.

Similarly, the Yankees manager, Joe Girardi, knows Jeter's batting average against right-handed pitchers at night and with runners on third base with less than two out in the seventh inning. So far in the game, Jeter has batted three times and was grounded out twice and has struck out once. Perhaps in the Yankees dugout is a substitute who has batted three times against Zambrano in the past and has two hits. Would Girardi substitute for Jeter in this situation? It is doubtful for a lot of reasons.

Who would replace Jeter at shortstop? Three times at bat is not statistically enough information to make a decision in such an important situation. Although Jeter is batting 0.000 and the substitute is batting 0.667 against Zambrano, it makes no sense to make the substitution.

Managers in business are faced with similar situations. They are bombarded with productivity information, and they must then make decisions that may be counter

to what the numbers say. Maybe the manager of baggage service for an airline gets a report that productivity is way down, that the number of bags handled per hour has dropped this week from the week before. However, the manager knows of other factors: The snowstorm that stopped planes one day explains the whole situation.

Virtually every job has some sort of productivity measurement that can be applied to it. The postman's productivity can be measured in volume of mail delivered per day, number of houses visited per day, or number of miles put on the car per day.

An attorney's productivity would be measured in some way to get billable hours. It could be obtained by seeing the results of the cases and comparing that with how much time and labor goes into each case.

If we were to measure the productivity of a police homicide department, we would look at the percentage of solved murders and then tie it to the number of labor hours per case.

At a supermarket, the cashier's productivity could be determined by the speed with which products are scanned and the percentage of items "rescanned." The productivity of commissioned salespersons is obviously measured by their sales, but is that the whole story?

To build a good productivity system, it is necessary to study the jobs, ask the employees to comment on the measurements, and consider combining a number of measurements into one productivity index.

Productivity Indexes

Sink (1985) derived a multiple measurement system called a **multiple-criteria measurement** (MCM) model. In this model, several measurements are aggregated into one score. In the following example, there are two measurements: output and quality. Each measurement is scaled, so that 10 points is the best possible score, 9 the next best, and so on (Table 2.4).

Table 2.4 Multiple-Criteria Index

Score	*Output (Pumpkins)*	*Quality (%)*
10	150	100
9	140	98
8	130	95
7	120	92
6	110	90
5	100	87
4	90	84
3	80	80
2	70	77
1	60	75
Weight	0.60	0.40

If a worker carved 127 pumpkins with 91% quality, the worker would receive a score of 7.7 for the output and 6.5 for the quality. Multiplying the measures by the weights, we get

$$(7.7 \times 0.6) + (6.5 \times 0.4) = 7.22.$$

The worker's score of 7.22 would be compared with the score of other workers doing the same job.

In professional football, quarterbacks are compared by using a similar measurement system. A scoring system is devised for a number of categories, and each quarterback is then indexed against this system. The categories are as follows: completion percentage (Cmp.), yards per attempt (Yds./Att.), percentage of touchdowns per attempt (TD), and percentage of interceptions per attempt (Int.).

According to www.nfl.com, the scores are derived in this way:

1. *Completion percentage:* Subtract 30 from the percentage of passes that are thrown for completions, and then multiply by 0.05.
2. *Yards per attempt:* Subtract 3 from the number of yards per passing attempt, and then multiply by 0.25.
3. *Touchdown percentage:* Multiply the percentage of touchdown passes per passing attempt by 0.2.
4. *Interception percentage:* Multiply the percentage of interceptions per passing attempt by 0.25, and then subtract 2.375 from that number.

The scores for each category are added together. The sum is divided by 6 and multiplied by 100, which converts it into a rating on a scale from 0 to 158.3.

Examples of quarterback scores from 2004:

	Yds.	*Att.*	*Cmp.*	*TD*	*Int.*	*Rating*
Manning, IN	4,557	497	336	49	10	121.1
Culpepper, MN	4,717	548	379	39	11	110.9

SOURCE: www.nfl.com

This is an example of an elaborate productivity system. A similar exercise could be applied to almost any worker.

In the case of a sales representative, we could consider actual sales, sales growth, market share in the territory, new customers, and retained customers.

Consider a real-estate agent. Total sales do not tell the whole story. It is also important that a high percentage of the homes listed are sold. Here is an example of a possible multicriterion index for an agent (Table 2.5).

Table 2.5 MCM for Real Estate

Score	*Total Sales ($)*	*Percentage of Listings Sold*	*Percentage of Lookers Who Buy*
10	3,000,000	100	20
9	2,500,000	95	18
8	2,000,000	90	15
7	1,500,000	85	12
6	1,000,000	80	10
5	750,000	75	7
4	500,000	70	5
3	400,000	65	3
2	350,000	60	2
1	300,000	55	1
Weight (%)	50	25	25

An agent whose sales total $1,750,000 in a year, with 60% of listings sold and 75% of customers buying, would score as follows:

	Score		*Weight (%)*
Sales	7.5	×	50
Percentage of listings	2	×	25
Percentage of buyers	5	×	25
Total score	5.5		

This score may be good or bad depending on how it compares with others of a similar background.

Time Studies

When studying the productivity of a worker, it is expected that the individual is performing his or her tasks in the most efficient manner possible. The field of industrial engineering is a discipline that studies work processes. There are several approaches to examining a job. The job must be broken down into micromotions, the actual movements of the hand or body.

To sign a piece of paper, a person has to do several motions:

1. Reach for the pen
2. Grasp the pen
3. Lift the pen
4. Write

It is to that level of detail that a number of micromotions are combined. Another way to add micromotions is to consult a predetermined table of motions.

Ultimately, a job is the combination of a number of different tasks. A professor's job includes these tasks:

1. Lecturing
2. Writing examinations
3. Grading examinations
4. Research
5. Committees
6. Planning vacations

A hotel front desk clerk's job includes these tasks:

1. Greeting registrants
2. Registering the guests
3. Credit card processing
4. Key distribution
5. Telling customers where the elevators are
6. Telling customers where the restrooms are

After all the tasks of a job are identified, there are several ways to study the worker's capacity to perform these tasks. One method is to do a **work sample**. A work sample involves studying the worker for a certain period of time. This could be done with a videotape. It is best that the worker does not know that he or she is being observed, because the actual act of observation can influence the performance.

For example, if we were to study a teller at a drive-through window of a bank, we might collect samples during the first 5 min of every hour the bank is open. From these observations, we can learn the following:

1. The percentage of time the teller is involved with customers
2. The rate of arrival of customers
3. The rate of service of the teller
4. Behaviors that may need correcting, for instance, flirting with customers and asking them for their phone numbers

A second way to study work is to do a **time study** with a stopwatch. If you want to learn how long it takes for a fast-food cashier to process an order of six items for a customer, we turn on the watch and time the transaction. Many order entry systems can do these calculations as transactions occur. The information system

can yield startling information of how different the productivity of two workers may be:

	Worker A	*Worker B*
Time at register (min)	220	220
No. of customers	68	142
Sales/customer	5.30	7.02

Worker B manages mores sales per customer, while also processing more than twice the number of customers.

Wiki Productivity

Wiki, software that allows users to add and edit inclusions in open Web pages, offers a new direction in workforce collaboration and decision making. Wikipedia is the biggest example of how a wiki works, with users continuously updating the Web encyclopedia. The same principle can be applied to the workforce.

> A new kind of business is emerging—one that opens its doors to the world, co-innovates with everyone (especially customers), shares resources that were previously closely guarded, harnesses the power of mass collaboration, and behaves not as a multinational but as something new: a truly global firm. These companies are driving important changes in their industries and rewriting many rules of competition. (Tapscott & Williams, 2006)

Wikinomics offers a more collaborative workplace, using the Web. In the United States, where the concept of quality circles, work groups that met after work to discuss solutions to business problems, did not catch on, wikis may help in resurrecting the concept.

Process Analysis

Work is the sum total of a number of processes. Whatever the job is, the operations manager must effectively design the movement of work through these processes.

The manager of the accounts payable function must process the payment of invoices in an efficient manner. The manager of the purchasing function must process the ordering of supplies and equipment. If a manager suspects that the process can be improved, an analysis should be undertaken. The first step in **process analysis** is to understand it. There are five steps involved. The five steps form an acronym: **DMAIC** (Define-Measure-Analyze-Improve-Control).

Step 1: *Define.* What process needs to be improved? Who will participate in the project for improving this process? Who are the customers? Who are the workers involved in the process? In this step, we interview customers and process workers to find out the scope of the project.

Step 2: *Measure.* In this step, we chart the process with some sort of flowchart or map. Input and output measurements are determined. Preliminary data are collected.

Step 3: *Analyze.* What causes problems? Reduce the list of causes.

Step 4: *Improve.* Find solutions for the problem, and design an implementation plan.

Step 5: *Control.* Make sure the improved process stays in control.

This chapter will focus on the first two steps, Define and Measure.

Define

A starting point for process improvement campaigns is to identify the processes that have the most impact on customers and the profitability of the firm. Process analysis can have a major financial impact; so it is crucial that time not be spent on nonessential activities. One fast-food restaurant chain did a process analysis to discover why one store in a region was much less profitable than the others. They discovered that the servers were passing out five or six catsup packets to each customer! Their solution was to place catsup and mustard dispensers in the store and cease to give out packets. The result was a savings of thousands of dollars per year!

The Process Project

This book devotes an entire chapter to project management. Once a project team is formed and the key processes have been identified, the team must learn about the existing process. In their book on Six Sigma processes, George, Rowlands, Price, and Maxey (2005) suggested a *Kaizen* approach to process improvement. ***Kaizen*** is a Japanese term that means, roughly, "continuous improvement." The definition stage alone involved the following:

- Defining the process objectives
- Selecting a project leader
- Preparing training materials
- Collecting information
- Planning logistics for meetings
- Covering for absences from the day-to-day workplace
- Arranging management participation
- Making appointments

Harrington (1991) outlined a number of questions to ask the workers involved in the process:

1. *What is your job description?* Some employees have not been told what exactly their job requires. A specific job description and a thorough orientation go a long way in starting a new employee off in the right direction.

2. *How were you trained?* Some problems with the process stem from improper training. With this question, the manager can find out if there were mistakes in the training of the worker and correct them.

3. *Who is your customer?* Many workers fail to see the link between their work and the worker who is next in line in the process. Fellow employees are "customers" of the work.

4. *What would happen if you were not at work?* This question addresses where the worker fits into the process. "If no one did my job, it wouldn't even be noticed" is not the correct reply. The order taker on the telephone has to have all the credit card information and an errorless order to pass on to the shipping workers who prepare the items for delivery.

5. *What prevents you from doing error-free work?* If mistakes are made, what causes them? An employee might answer that there is a simple solution—get me a taller chair!

6. *What would you do if you were the manager?* Employees are much like Monday-morning quarterbacks, who criticize every move of the football coach in the game the day before. Workers go home to their families and complain about the mistakes made by their idiot managers! They then espouse a number of ideas to their families that may have some merit. "OK, if you were in charge, what would you do?" They may be suspicious and think this is a trick question, but the idea is to get them to open up.

7. *What do you do?* A different question from the job description one—this question asks for a real explanation of job duties. This description may differ from the job description and may reveal that the process worker is doing some wrong things.

8. *How do you know your output is good?* All workers should be given an explanation of what constitutes good work. Sometimes they are working without knowing this all-important definition of a quality standard to attain.

9. *How can we make your job easier?* They may never have been asked if there were some actions management could take to help them do a better job. They certainly would appreciate the question.

These are important questions the operations manager should ask, so that he or she can truly understand how the work is getting done.

The Voice of the Customer

After interviewing the process workers, the customer should be consulted for suggestions. First, the process analyst must find the *right* customers to ask. That

means some market research to determine who the customers who buy the product or use the service are.

One Saturday morning at the bagel shop is probably adequate to gather such information, if it is the bagel restaurant you want to study.

Questions to ask the customer:

1. Why do you come here?
2. What improvements would you suggest to the store?
3. What are your favorite aspects of the place?
4. What are your favorite products?
5. Are you dissatisfied with any of the services that are offered?

Many times, customers can see things that companies cannot. After all, most of their customers have their own workplaces that they can compare on business processes.

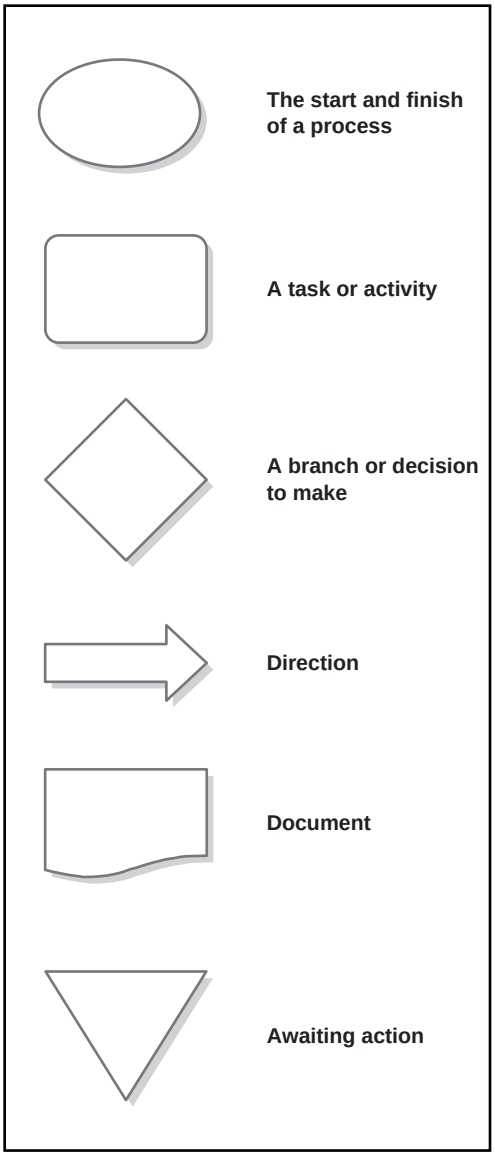

Figure 2.1 Flowchart Icons

SOURCE: Leinaker, Sanders, and Hild (1996) and Tenner and DeToro (2000).

Measure

A beginning point in the measurement phase of process analysis is to draw a picture. There are a number of different charting methods. A flowchart of the process is a helpful approach to detect inefficient actions. There are several basic charting symbols, including the most basic ones shown in Figure 2.1.

Other types of charting methods include the following:

- *Value stream mapping:* Identifies value-added and non-value-added activities and includes some performance data.
- *SIPOC diagram (suppliers, inputs, process, outputs, customers):* Provides a complete analysis of inputs and outputs that goes from the supplier of the process to the customer of the process.
- *Deployment flowchart:* Arranges processes according to functions (purchasing, accounts payable, etc.).
- *Transportation diagram:* Provides a diagram of work flow (see Figure 2.2).

The Process of Making Red Wine

All products follow a production process in a sequence of steps. The making of red wine, which is different from the process of making white wine, by necessity starts with the selection of the vineyard and the grape. The location is key to the success of the wine because the soil, the sunlight, and the climate are important factors.

After the grapes are picked, the stems are removed (but not always), and the grapes are crushed. The crushed grapes are placed inside a tank, and yeast is added. Fermentation of the grapes begins, and skins are placed over the liquid. After fermentation is complete, the wine is pressed, put in barrels, and aged. Finally, it is bottled.

This sounds like a simple process; yet every year, the wine tastes different from two next-door neighbors making cabernet sauvignon. That is why there is still an element of art in the winemaking process.

Compare winemaking with the process of making a McDonald's French fry. These fries taste the same everywhere in the world. It is doubtful if we will see a day when we have French fry connoisseurs conducting taste tests and pronouncing the year the French fry was made and what part of Idaho the potato came from.

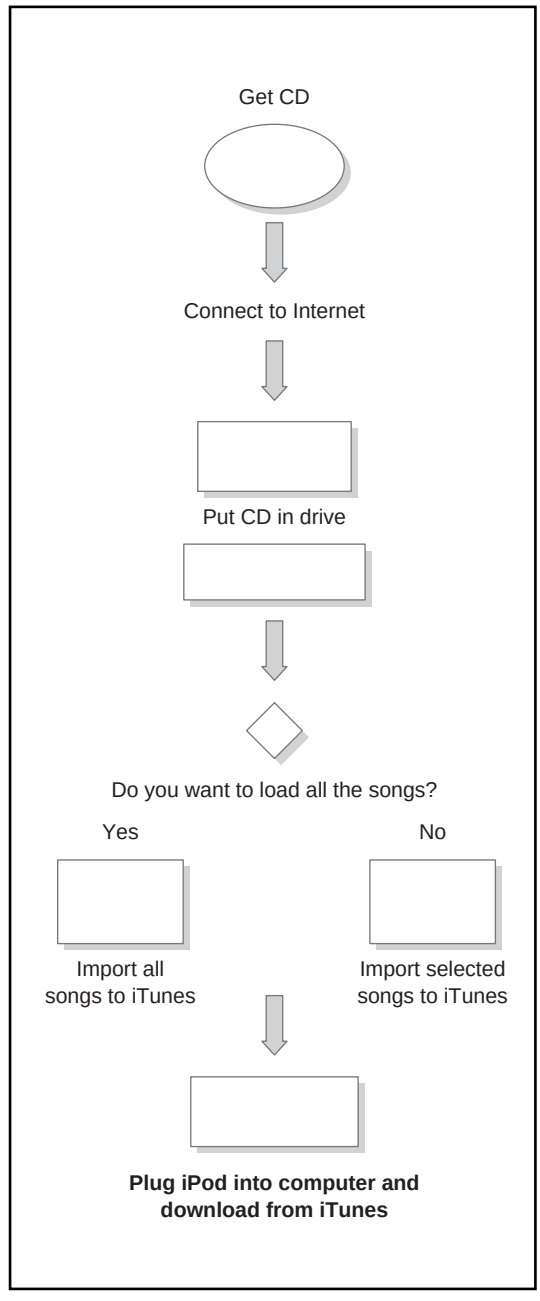

Figure 2.2 Example of Process: Transferring a CD to an iPod

UPS 12-Step Unloading Process

UPS goes to great lengths to streamline the process of delivering packages. The process of delivering one package from a shelf involves 12 steps:

1. Shift into the lowest gear or park.
2. Turn off the ignition and engage the parking brake.
3. Release the seat belt with the left hand.
4. Open the door.

5. Place the key on the ring finger.
6. Select the package.
7. Only select packages from the selection area.
8. Close the door.
9. Pick up the DIAD (delivery information acquisition device).
10. Fasten the DIAD to the belt clip.
11. Look both ways before stepping into the street.
12. Hold on to the handrail and exit the truck.

The UPS industrial engineers have determined that picking a package from a shelf should take 15.5 s and from the floor, 25.1 s. Picking three packages from a shelf should take 29.6 s and five packages from the rear door, 65.5 s.

The very action of Step 5 is instructive. Without the routine of going through these 12 steps over and over again, it becomes very easy to absentmindedly misplace the car keys. How embarrassing it would be for a UPS driver (Hira, 2007) to have to call for a new key! But they are human like the rest of us, who are always losing keys, checkbooks, and eyeglasses. For those with a tendency to lose things, the best approach is to always perform the same steps. Every day, the keys are placed in the same location. If you forget and leave them in a coat pocket, it leads to a panic-stricken search for them the next day!

How to Analyze a Process

Getting From Home to the Airport

There are a number of decision points and processes involved in getting from your home, office, or hotel to your scheduled flight at the airport:

Decision Point 1: What time is the departure? The time of departure can affect what transportation method one takes to the airport. If the flight is before or after the rush hour, traffic is reduced, making the drive or taxi ride a speedy alternative.

Decision Point 2: How many bags will you carry, and how many bags will you check in? If you opt to check bags on the plane, it will add some time for processing the bags. If you have a number of bags, carrying them around becomes a hassle, and a taxi looks like a desirable alternative.

Decision Point 3: How will you get there? Compare some transportation options available for one commuter to Chicago's O'Hare airport:

Transportation Option	*Cost ($)*	*Avg. Time*
Electric train	3.50 return ticket	1 hr 40 min (varies by location)
Taxi	36.00	30 min
Drive and park	16/day	48 min
Someone drops you	6	30 min

If the commuter is cost sensitive and has the time, the electric train is a great option. On the other hand, carrying four suitcases and transferring trains would make it a drag—in more ways than one!

Decision Point 4: Will you carry your laptop? If so, this adds hassle at the airport, adds a bag to your luggage, but gives you a portable office on location.

Decision Point 5: Do you check in with the sky cab or go to the automated kiosk? If you only have carry-on luggage, the lines are shorter.

Decision Point 6: Will you eat or buy magazines/books prior to the metal detectors or after? Similarly, do you use a restroom prior to the metal detectors or after? The first question is easy to answer if there is a rule of thumb: If the flight boards in less than an hour, go through the detectors first. On the second issue, only your bladder knows for sure.

Decision Point 7: Do you board as soon as your seating area is announced, or do you hang out until the last minute? That, again, depends on whether you have luggage to stow.

The sometimes mad rush to the airport can be avoided if one has carefully outlined this process and determined the answers to these decision points in advance.

The Process of Getting U2 Tickets

Getting a ticket for popular sporting events and concerts can be a challenge. One method has been to assign a wristband to potential ticket buyers, then randomly assign a numbered wristband to begin the line of ticket sales.

The Irish group U2 tried a method of ticket sales that backfired. They told concertgoers that they could join the U2 fan club for $40 and get advance sales of concerts. What U2 did not realize was that so many people thought it was infinitely better to pay the $40 than it was to stand in line that so the fans who paid the money outnumbered the concert's total capacity by a wide margin. In fact, few of them procured tickets.

It was an unfortunate way to discover that a new process was worse than the old one.

The Process of Getting Elected President of the United States

If you are a U.S. citizen, there is a complicated process in getting elected president. Before the process even begins, the candidate must have minimally good looks, a lot

of money, and friends in high places and must not have any secret affairs or be involved in business scandals. The best candidate will probably have been a member of the Boy Scouts or Girl Scouts, played several sports growing up, had a sterling grade point average through school, been loved by all teachers, and either made a fortune in business or inherited a lot of money. The candidate will most likely be married, with 2.2 children and a dog. Unless the candidate lives in California, he or she will probably have spent some time in a political office, such as governor of the home state or U.S. senator. The person should not have extreme views, left wing or right wing, on any issue.

Once all these ingredients are in place, the fun begins. Here are some key steps of the process:

1. Conduct a feasibility study. The candidate should commission a study to ascertain his or her chances of getting elected. Does the candidate have name recognition in all regions of the United States?

2. Build a staff. The candidate needs several key people, a campaign manager, a budget manager, a public relations adviser, an issues adviser, and a speechwriter or two.

3. Take positions on every potential campaign issue imaginable. Voters will want to know what you think of farm aid, foreign aid, and Band-Aid.

4. Invade the states that have the preliminary primaries. Without victories in the early primaries, the chances of gaining momentum through the convention are slim. The public relations team must find every conceivable way to get free ink and airtime.

5. Fund-raising continues at an increasing rate if the early primaries are positive.

6. Establish a national staff. The staffers must find important individuals in every state who are willing to make an early commitment to your campaign and spend the time to organize support and funds in their home states.

7. Gain momentum. If the challengers slowly self-destruct and withdraw from the race, ask each of them to join your team in exchange for some good tickets to future U2 concerts.

8. Work the convention. The convention is where supporters are supposed to follow through with their promised-for votes. A lot of wining and dining and promising go on here.

9. Don't say anything stupid between the convention and the election that will offend any constituency in any state.

10. Have an acceptance speech and a concession speech at hand on election night.

11. If you win, you are the next president. If you lose, write a book about the experience. If you lost weight while campaigning, write a book on weight loss.

In Chapter 15, you will notice many similarities between process analysis and projects. An election campaign is a process in that you must successfully follow a

series of steps to win the election. It is also a project with many tasks that can be handled simultaneously.

Streamlining

Harrington (1991) suggested a number of approaches for **streamlining** processes:

1. Eliminate bureaucracy. Organizations seem to love to make things complicated, adding layers of management that become bottlenecks to progress.

2. Eliminate duplication. The process analyst should look for places where work may be duplicated, and eliminate the excess.

3. Assess value added. The most important process improvements should be aimed at those processes in which value is added to the customer. These improvements will have the biggest financial impact.

4. Simplify. The old acronym KISS (Keep it simple, stupid!) applies at all times.

5. Reduce cycle time. Make it a goal to reduce process time while improving efficiency.

6. Proof errors. The operations manager must "idiot-proof" a process. This must be done by imagining how a stupid person will mess it up. For example, the IRS places a message on the return envelope, "Did you remember to sign?" This message helps protect them against the most frequent error in income tax statements. If you build an airplane, you have to assume that some day someone will want to see if the plane's emergency door will open in midflight; so the engineers have to design a door that will not open unless the plane is on the ground.

7. Simplify language. Business language should be aimed at the elementary-grade level of understanding. Some document writers like to display their impressive vocabularies, and mistakes are made because the workers do not understand the words.

This is an actual real-estate document:

> . . . title company, a state corporation, as duly appointed trustee under deed of trust hereinafter referred to, having received from the holder of obligations thereunder a written request to reconvey, reciting that all sums secured by said deed of trust and the note or notes secured thereby having been surrendered to said trustee for cancellation, does hereby reconvey, without warranty, to the person or persons legally entitled thereto the estate now held by it thereunder.

Do you use these words on a daily basis? *Thereunder, hereinafter, reconvey*? Perhaps these were used in the days of Shakespeare but certainly not today. "Would you reconvey me a cup of coffee?" "I want to marry you for the hereinafter!" Documents like these require attorneys to understand them, so perhaps some of you will go to law school and make a living interpreting them.

Pitfalls in Process Analysis

Jacka and Keller (2002), who advocated what they called *process mapping*, a variation of flowcharting, in their book *Business Process Mapping*, identified a number of pitfalls that can occur during process analysis:

1. *Mapping for mapping's sake:* Creating flowcharts is not the objective of process analysis; improving the process is the goal. Some analysts get caught up so much in flowcharting that they can't see the forest for the trees.
2. *Creating complicated flowcharts that are difficult to read.*
3. *Letting the customer define the process:* Customers can get an analyst offtrack before a conclusion is made.
4. *Not verifying the facts:* An error in charting can lead to the wrong results. Charts should be checked and rechecked for accuracy.

Process Analysis and Lean

The process of analyzing processes with flow diagrams and analyzing the way work is accomplished is an important step in **LEAN production**. This term was first used by the authors James Womack and Daniel Jones in their book *The Machine That Changed the World* (1991) and further defined in their book *Lean Thinking* (2003). This concept, which will be discussed later in this book, is essentially nothing more than a renaming of the Japanese production system, just-in-time (JIT).

The principal aim is to eliminate waste, or ***muda***, the Japanese word for waste. This is accomplished by identifying the value stream, the "set of actions required to bring a specific product (whether a good or service, or increasingly, a combination of the two) through the three critical management tasks of any business (Womack & Jones, 2003, p. 19).

After the value stream is identified, wasteful steps are eliminated, and a continuous flow is created. Womack and Jones (2003) pointed out that continuous flow is counterintuitive because work tends to be completed in batches. Womack illustrated this with an example of his daughters, who mailed a newsletter in the following steps:

1. Fold the newsletter.
2. Put on the address labels.
3. Seal the newsletter by sticking the upper and lower parts for mailing.
4. Then put on the stamps.

The daughters established four workstations for the process and passed the newsletter down the line. Womack's alternative method was to perform the four steps on each newsletter, so rather than pass the paper down the line, each line did

the four steps individually. His argument was that the wasteful step of four people picking up the piece of paper was eliminated.

Summary

- Productivity is defined as the ratio of outputs to inputs.
- Every industry has its important productivity measurements. A hospital may be concerned with its occupancy rate and mortality rate. An airplane deals with its seat utilization and on-time arrivals and departures. A police department is concerned with minimizing the number of crimes committed.
- Sports offer a glimpse of how to manage given a plethora of productivity measurements, since sports statistics are exactly that. The way a baseball manager makes decisions based on data is not much different from the way a manufacturing manager examines the productivity of workers.
- The multiple criteria measurement index is a way to combine a number of factors into one measurement system.
- Time studies serve as a mechanism to study the amount of time in which a work task can be performed. They are helpful in improving productivity by providing information on what a worker can accomplish.
- Wiki productivity holds potential as a new form that can increase worker collaboration.
- A process analysis involves a thorough study of a process, including diagramming and interviewing process workers.
- DMAIC is a method of improving a process that involves the following steps: Define-Measure-Analyze-Improve-Control.
- Streamlining is an approach to process improvement through process analysis.
- Pitfalls of flowcharting include the tendency to rely too much on charting.
- Process improvement is critical in the success of lean production, or JIT, which emphasizes the elimination of waste.

Key Terms

DMAIC
Kaizen
Lean production
Muda
Multiple-criteria measurement
Process analysis
Streamlining
Time study
Voice of the customer
Wikinomics
Work sample

Review Questions

1. Define production and operations management.
2. Compare operations management in a hospital with operations in a steel mill.
3. How did Frederick Taylor, the Gilbreths, and the Hawthorne study contribute to modern-day operations management?
4. What is a multicriteria performance index, and how does one analyze the score?
5. What are micromotions?
6. How do you define a job?
7. What is the difference between average time and standard time?
8. What are the best questions to ask a worker in a process?
9. List the methods of streamlining a process.
10. How can wiki software increase productivity in an organization?

Projects

1. Consult a company you are familiar with. Who is "the operations manager"? Ask the person to describe his or her activities.

2. Spend the day observing operations management at work, during your commute, where you study, and where you dine.

3. Find out who sets up the college's class schedule, and ask the person how he or she goes about it.

4. Go to a retailer and discuss with the manager how merchandise is purchased and displayed.

5. Devise an MCM system for a worker at a fast-food restaurant who assembles burgers and other sandwiches, operates the cash register, and cleans the area.

6. Ask a librarian what the main activities of work are, and devise an MCM system for the job.

7. In a sport other than football, devise an MCM system of performance.

8. Ask a woman to tie a necktie. Use a stopwatch to see how fast she does it the first time. Try it again. What is the average time? For men, see how long it takes to put on panty hose. Try it a second time. How well does men's performance compare with women doing the same task?

9. Analyze a process by interviewing process workers and then drawing a flowchart of the work. Criticize the process.

10. Approach a process and make streamlining suggestions.

11. Study the following processes: getting a driver's license, buying a house, selling a house, applying for a car loan, washing your clothes at a Laundromat. Draw flowcharts, and see if you can detect flaws in the process.

CASE 1 Process Diagramming—Double-Chocolate Cookies

Use the diagramming icons to draw a picture of this cookie recipe:

1. Sift together the flour, cocoa, baking powder, and salt in a medium bowl. Set aside.

2. Melt the chocolate in a medium heatproof bowl set over a pan of almost simmering water, stirring once or twice until smooth, and then remove from the heat. In a small bowl, beat the eggs and vanilla lightly with a fork; sprinkle the coffee powder over to dissolve, and set aside.

3. Either by hand or with an electric mixer, beat the butter at medium speed until smooth and creamy, about 5 s. Beat in the sugars until combined, about 45 s. Add the chocolate in a steady stream and beat until combined, about 40 s. Scrape the bottom and sides of the bowl with a rubber spatula. With the mixer at low speed, add the dry ingredients and mix until just combined. Do not overbeat. Cover with plastic wrap and let stand at room temperature until the consistency is scoopable and fudge-like, about 30 min.

4. Meanwhile, adjust the oven racks to the upper- and lower-middle positions, and heat the oven to 350°. Line two baking sheets with parchment paper. Scoop the dough onto the prepared baking sheets with a 1½-in. ice-cream scoop, spacing the mounds of dough about 1½ in. apart.

5. Bake until the edges of the cookies have just begun to set but the centers are still very soft, about 10 min, rotating the baking sheets front to back and top to bottom halfway through the baking time. Cool the cookies on the sheets, about 10 min, slide the parchment with the cookies onto wire racks, and cool to room temperature. Cover one cooled baking sheet with a new piece of parchment paper. Scoop the remaining dough onto the parchment-lined sheet, bake, and cool as directed. Remove the cooled cookies from the parchment with a wide metal spatula.

Makes about 42 cookies.
Ingredients:

2 cups (10 oz) unbleached all-purpose flour

½ cup (1½ oz) Dutch-processed cocoa

2 teaspoons baking powder

½ teaspoon salt

16 oz semisweet chocolate, chopped

4 large eggs

2 teaspoons vanilla extract

2 teaspoons instant coffee or espresso powder

2 tablespoons unsalted butter, softened but still cool

1½ cups light brown sugar

½ cup granulated sugar

How is preparing a recipe like a business process? Was this recipe easy to diagram?

SOURCE: Adapted from *The New Best Recipe* (2004, pp. 779–780).

CASE 2 The Eight Days a Week Fitness Center

King Kwong has owned and operated the Eight Days a Week Fitness Center in Hong Kong for several years. The Fitness Center is located near a shopping mall and City University of Hong Kong and draws a number of students, working professionals, and residents of Kowloon. It is across the street from a railway station and is ideally located. The Fitness Center showed a profit by its second year, and its membership grew rapidly. The Center was able to pay off most of its equipment within the first year, but there were signs of discontentment from the members, who complained of there not being enough towels and about problems with the cleanliness of the locker room.

King decided to study the situation and take whatever course of action he could to correct the situation. Here are some of his figures:

Month and Year	*No. of Members*	*No. of Employees*	*Avg. Labor Hrs/Employee*	*Profit (in HK $)*
Jan. 2006	850	25	4.8	–27,000
Feb. 2006	1,420	40	4.4	–22,000
Mar. 2006	2,107	53	4.7	–13,000
Apr. 2006	2,745	56	5.2	–6,000
May 2006	2,987	65	4.9	–3,000
Jun. 2006	3,005	70	4.6	1,005
Jul. 2006	3,017	68	4.5	3,000
Aug. 2006	3,030	65	4.6	7,000
Sep. 2006	3,045	62	4.7	15,000
Oct. 2006	3,030	65	4.7	22,000
Nov. 2006	3,027	64	4.5	25,000
Dec. 2006	3,009	65	4.6	29,000
Jan. 2007	3,302	74	4.4	40,000
Feb. 2007	3,290	72	4.3	34,800

For the same period, here are his laundry and housekeeping expenses:

Month and Year	*Laundry (HK$)*	*Housekeeping (HK$)*
Jan. 2006	6,000	11,420
Feb. 2006	7,100	11,804
Mar. 2006	8,200	13,300
Apr. 2006	9,300	15,600
May 2006	9,700	18,200
Jun. 2006	9,600	17,900
Jul. 2006	9,600	18,100

Month and Year	*Laundry (HK $)*	*Housekeeping (HK $)*
Aug. 2006	9,400	17,700
Sep. 2006	9,100	16,500
Oct. 2006	8,700	16,000
Nov. 2006	8,500	15,800
Dec. 2006	8,600	16,000
Jan. 2007	9,100	16,400
Feb. 2007	9,200	16,600

In December 2006, King asked members to complete customer service questionnaires. On a scale of 1 to 5, with 5 = *most satisfied*, the members gave the following ratings:

	Dec. 2006	*Jan. 2007*	*Feb. 2007*
Locker room facilities	3.40	3.30	3.20
Equipment	4.50	4.50	4.35
Fitness staff support	4.90	4.87	4.91
Janitorial staff support	2.20	2.10	2.05
Cleanliness of facility	2.75	2.87	2.56
Exercise classes	3.67	3.45	3.27

Given this information that King has collected, do as follows:

1. Derive a number of productivity ratios that are important to the club.
2. Identify problem areas for King to address.
3. Are there relationships between profitability and service at this institution?

CASE 3 Mehdi's Car Wash

Dr. Mehdi decided to take a break from teaching and invest in a South Florida car wash. He was interested in the productivity of the workers at the car wash, so he studied the number of cars washed versus the number of workers employed every hour for a week. The following table gives the information he collected. What are the productivity rates per hour, and how do they differ across the week?

Time Period	*Cars Washed*	*Workers*
7:00 a.m.–7:59 a.m.	6	4
8:00 a.m.–8:59 a.m.	14	8
9:00 a.m.–9:59 a.m.	16	8

(Continued)

(Continued)

Time Period	*Cars Washed*	*Workers*
10:00 a.m.–10:59 a.m.	20	8
11:00 a.m.–11:59 a.m.	24	8
12:00 p.m.–12:59 p.m.	42	10
1:00 p.m.–1:59 p.m.	30	10
2:00 p.m.–2:59 p.m.	20	8
3:00 p.m.–3:59 p.m.	35	8
4:00 p.m.–4:59 p.m.	32	8
5:00 p.m.–5:59 p.m.	31	8
6:00 p.m.–6:59 p.m.	37	8
7:00 p.m.–7:59 p.m.	12	6

What staffing considerations might Mehdi consider? If each car wash averages $12, the workers are paid $5 per hour (not including tips), and nonlabor expenses (supplies, overhead, etc.) are $800 per day, what is the expected profit for Mehdi?

CASE 4 Rohit's Pizza

Rohit wants to compare the productivity of his pizza delivery drivers. His company covers an 8-mile radius, and drivers take the orders as they come.

In a 1-week period:

Driver	*Deliveries*	*Hours Worked*
Abe	62	30
Buffy	47	30
Adrian	58	30
Rocky	39	24
Sam	48	24
Boris	33	24
Bo	40	24
Tommy	38	20
Elliott	36	20
Missy	45	20

Calculate the productivity rates for each driver.

CASE 5 Hospital Supply Marketing

Caron is a new marketing representative for a hospital supply company. She has a starting salary of $48,000, but after 1 year the salary structure changes to $36,000 plus 5% of total sales. As she reviews her sales for her first year, she is somewhat anxious about her earnings in the next year.

From a productivity standpoint, answer the following:

1. How would you devise an MCM system for a marketing representative that included other variables besides sales?
2. What is the projected income for Caron in the coming year?
3. Should Caron get another job?

Quarter	*Sales ($)*
1	27,000
2	29,000
3	31,000
4	36,000

CASE 6 Office Productivity

Wing designed a new productivity system for his development office in an effort to increase fund-raising for his university. Each development staff member was to receive a 3% commission on all donations actually collected. It did not matter whether the staffer solicited the donation or not. Here is a comparison of the year prior to implementation of the system and the year after it was implemented:

	2005	*2006*
Alexandra, Education	175,000	188,000
Bruce, Liberal Arts and Sciences	240,000	310,000
Ed, Business	607,000	547,000
Mildred, Computer Science	100,000	156,000
Kathy, Law	588,000	1,200,000

How much did each staffer earn in commissions? Did the system appear to be working?

Web Sites

The American Productivity and Quality Center: www.apqc.org

The Australian Productivity Commission: pc.gov.au

European automotive production: http://Worldmarketanalysis.com

Explanation of NFL statistics: http://Slate.msn.com

Hong Kong Productivity Council: www.hkpc.org

Marriott Hotel productivity information: www.marriott.com/corporateinfo

Pro football: www.nfl.com

United Kingdom Productivity: statistics.gov.uk

U.S. Bureau of Labor Statistics: www.bls.gov

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