METHODS ENGINEERING AND WORK MEASUREMENT 0906384

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Dr. Shahd Obeidat

Background

- The industrial revolution started in England around 1770 with the invention of several new machines.
- The population in 1900 was 76 million and growing and by 1920 exceeded 102 million. Mass production were primary to cover the increased demand.
- The need for production line management have arisen and the science of method engineering and work measurement became essential.
- The need to plan and control the large number of activities and workers required the time and motion study.

The scientific management movement

- The scientific management movement started back in the United States.
- The scientific management movement members are:
  - *Frederick W. Taylor*
  - *Frank Gilbert*
  - *Lillian Gilbreth*

- The principal approach of the movement:
  - *(1) motion study, aimed at finding the best method to perform a given task and eliminating delays*
  - *(2) time study to establish work standards for a job*
  - *(3) extensive use of standards in industry*
  - *(4) the piece rate system (workers paid per unit performed) and similar labor incentive plans*
  - *(5) use of data collection, record keeping, and cost accounting in factory operations*

Father of scientific management

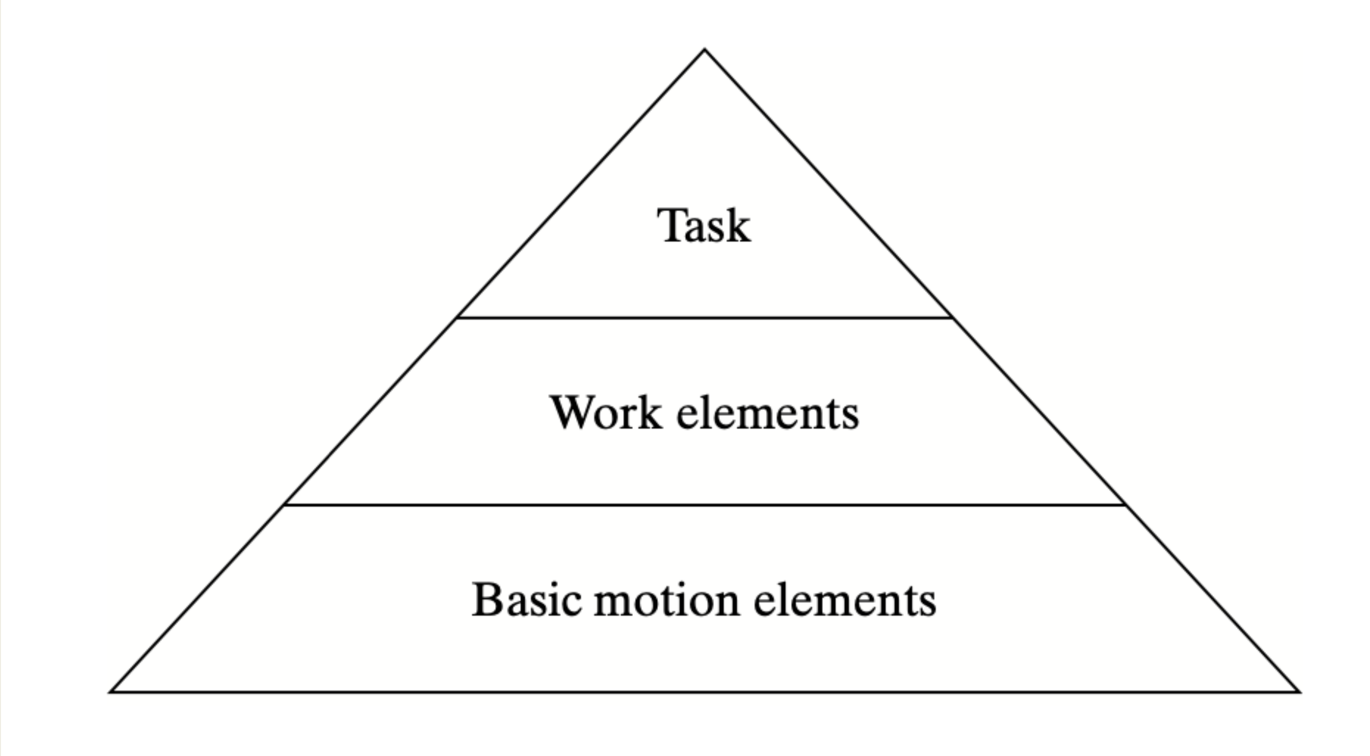
- ***Frederick W. Taylor*** (1856–1915) is known as the "**father of scientific management**" for his application of systematic approaches to the study and improvement of work. His findings and writings have influenced factory management in virtually every industrialized country in the world, especially the United States.
- ***Frank Gilbreth*** (1868–1924) is noted for his pioneering efforts in analyzing and simplifying manual work. He was associated with the scientific management movement in the late 1800s and early 1900s, in particular for his achievements in motion study. He is sometimes referred to as the "**father of motion study**." Two of his important theories about work were (1) that all work was composed of 17 basic motion elements that he called "therbligs" and (2) the principle that there is "one best method" to perform a given task.

Father of scientific management

- ***Lillian Gilbreth*** (1878–1972) was the oldest of nine children. She earned bachelor's and master's degrees at the University of California, Berkeley. During her marriage to Frank, she became the mother of 12 children and earned a doctorate at Brown University in 1915, a rare achievement for a woman at the time. Her other accomplishments were equally noteworthy. With her husband, she co-authored four books: ***A Primer of Scientific Management*** (1914), ***Fatigue Study*** (1916), ***Applied Motion Study*** (1917), and ***Motion Study for the Handicapped*** (1917). On her own, she wrote ***The Psychology of Management*** (1914) and several other books after Frank's death.
- The story of how Frank and Lillian Gilbreth practiced efficiency and motion study in their own home was humorously documented by two of their 12 children in 1949 with the publication of ***Cheaper by the Dozen.***

The nature of work

- The pyramidal structure of a task. Each task consists of multiple work elements, which in turn consist of multiple basic motion elements.



The nature of work

- ***Work*** is defined as an activity in which a person exerts physical and mental effort to accomplish a given task or perform a duty.
- A ***task*** is an amount of work that is assigned to a worker or for which a worker is responsible.
- A task may involve one or more steps in making a product or delivering a service. The worker performing the task must apply certain skills and knowledge to complete the task or duty successfully.
- The task can be repetitive (as in a repetitive operation in mass production) or nonrepetitive (performed periodically, infrequently, or only once).

The nature of work

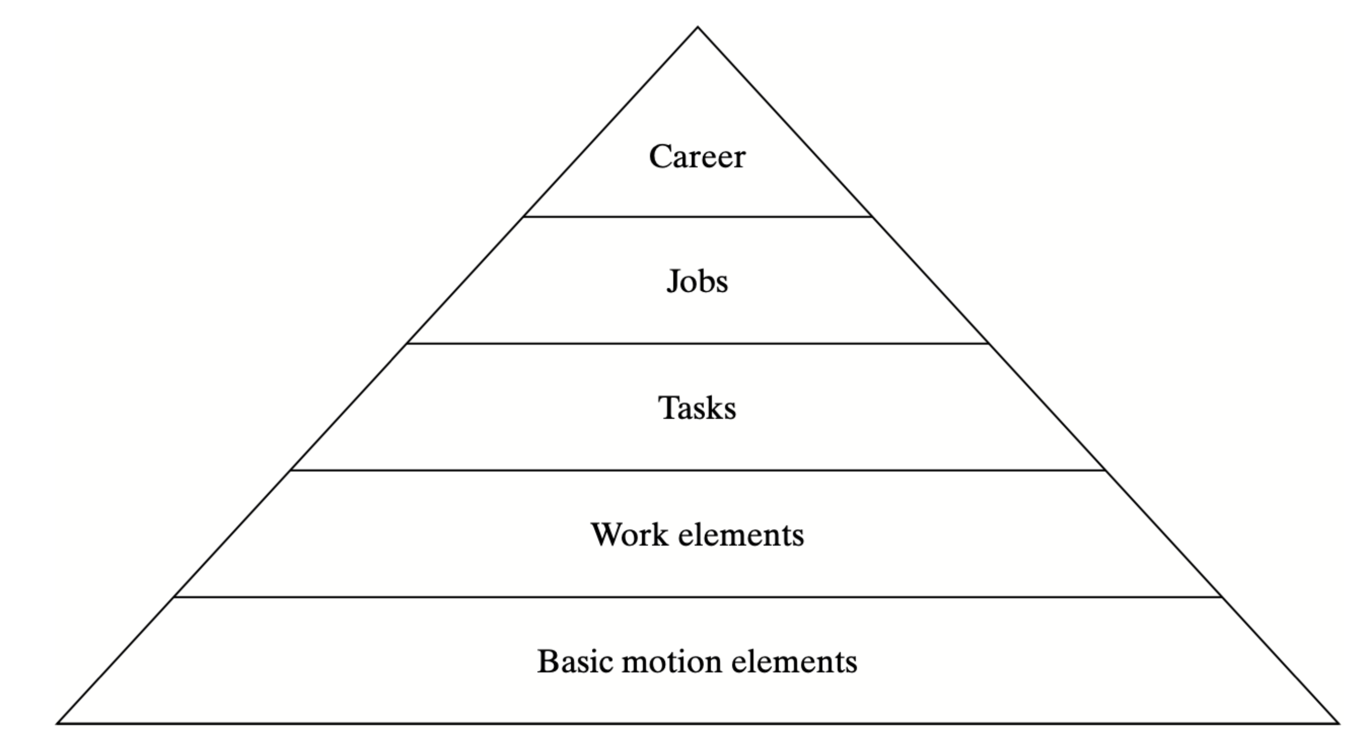
- ***Basic motion elements*** are actuations of the limbs and other body parts while engaged in performing the task. These basic motion elements include reaching for an object, grasping an object, or moving an object. Other basic motions include walking and eye movement (e.g., eye focusing, reading).

- ***Work element*** is defined as a series of work activities that are logically grouped together because they have a unified function within the task. For example, a typical assembly work element consists of reaching for a part, grasping it, and attaching it to a base part, perhaps using one or more fasteners (e.g., screws, bolts, and nuts).

- Work elements usually take six seconds or longer, while a basic motion element may take less than a second. The entire task may take 30 seconds to several minutes if it is a repetitive task, while nonrepetitive tasks may require a much longer time to complete.

The nature of work

- The pyramidal structure of work.



The importance of time

- Time is important in business and industry, as the following examples demonstrate:
  1. *New product introduction. The manufacturer introducing a new product to the market in the shortest time is usually the one rewarded with the most profits.*
  2. *Product cost. In many cases, the number of labor hours required to produce a product represents a significant portion of total manufacturing cost, which determines the price of the product. Companies that can reduce the time to make a product can sell it at a more competitive price.*
  3. *Delivery time. A long with cost and quality, delivery time is a key criterion in vendor selection by many companies. The supplier that can deliver its products in the shortest time is often the one selected by the customer.*
  4. *Over night delivery. The success of overnight delivery offered by parcel transport companies (e.g., UPS, Fed Ex) illustrates the growing commercial importance of time.*

The importance of time

- Time is important in business and industry, as the following examples demonstrate:

  5. Competitive bidding. In many competitive bidding situations, proposals must be submitted by a specified date and time. Late proposals will be disregarded.

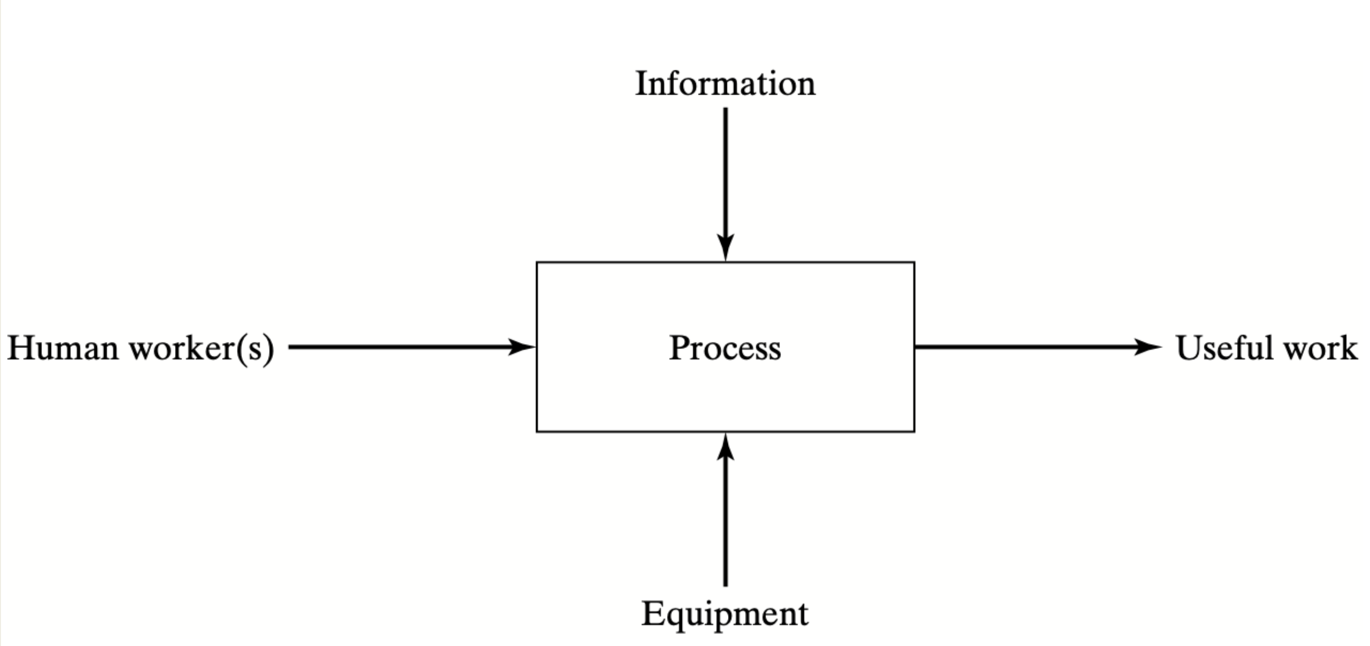
  6. Production scheduling. The production schedule in a manufacturing plant is based on dates and times.

  Time is important in work. The many reasons why this is so include the following:

  - *The most frequently used measure of work is time. How many minutes or hours are required to perform a given task?*
  - *Most workers are paid according to the amount of time they work. They earn an hourly wage rate or a salary that is paid on a weekly, biweekly, or monthly basis.*
  - *Workers must arrive at work on time. If a worker is a member of a work team, his or her absence or tardiness may handicap the rest of the team.*

Physical Work Systems

- As a physical entity, a ***work system*** is a system consisting of humans, information, and equipment that is designed to perform useful work.



Work Systems as a Field of Professional Practice

- work methods
- work measurement
- work management.

Work Systems as a Field of Professional Practice

- ***Work methods*** consists of the analysis and design of tasks and jobs involving human work activity. Terms related to work methods include ***operations analysis*** and ***methods engineering***. ***Motion study*** is also used, but its scope is usually limited to the physical motions, tools, and workplace layout used by a worker to perform a task.

- ***Work measurement*** is the analysis of a task to determine the time that should be allowed for a qualified worker to perform the task. The time thus determined is called the ***standard time***. Among its many applications, the standard time can be used to compute product costs, assess worker performance, and determine worker requirements (e.g., how many workers are needed to accomplish a given workload). **Cont …**

Work Systems as a Field of Professional Practice

- **Cont…** Because of its emphasis on time, work measurement is often referred to as time study. However, in the modern context, ***time study*** has a broader meaning that includes work situations in which an operation is performed by automated equipment, and it is desired to determine the cycle time for the operation.

- Time is important because it equates to money ("time is money," as the saying goes), and money is a limited resource that must be well managed in any organization.

Work Systems as a Field of Professional Practice

- ***Work management*** refers to the various organizational and administrative functions that must be accomplished to achieve high productivity of the work system and effective supervision of workers. Work management includes functions such as:

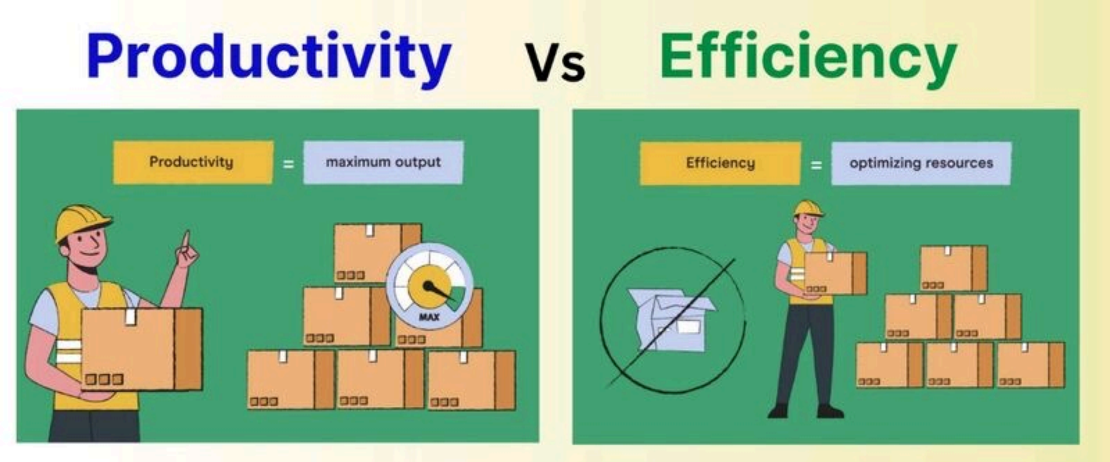
1. organizing workers to perform the specialized tasks that constitute the workload in each department of the company or other organization.
2. motivating workers to perform the tasks.
3. evaluating the jobs in the organization so that each worker is paid an appropriate wage or salary commensurate with the type of work performed.
4. appraising the performance of workers to reward better-performing workers appropriately.
5. compensating workers using a rational payment system for the work they perform.

TABLE 4 Comparison of Work Characteristics of Four Categories of Workers

Worker Category	Production Workers	Logistics Workers	Service Workers	Knowledge Workers
Basic functions	Make products	Move materials, products, or people	Provide service Apply information and knowledge Communicate	Create knowledge Solve problems Manage and coordinate
Type of work	Mostly physical	Mostly physical	Mostly cognitive	Mostly cognitive
Worker discretion	Limited	Limited to moderate	Moderate to broad	Broad
Equipment required for basic work	Machinery systems (production tools and machines)	Machinery systems (transportation, material handling)	Computer systems Communication systems	Computer systems Information resources
Industry and professional examples	Manufacturing Construction Agriculture Power generation	Transportation Distribution Material handling Storage	Banking Government service Health care Retail	Management Designing Legal Education Consulting
Representative positions and job titles	Laborer Machine operator Assembly worker Machinist Quality inspector Construction worker	Truck driver Airplane pilot Ship captain Material handler Order picker Shipping clerk	Bank teller Police officer Nurse Physical trainer Salesperson Foreman	Manager Physician Designer Researcher Lawyer Teacher

Productivity

- ***Productivity*** is defined as the level of output of a given process relative to the level of input.
- ***Productivity*** is a measure of economic performance.
- ***Productivity*** is the efficiency of production of goods or services.



Productivity	Efficiency
• Measure of how much output is produced given a certain amount of inputs and resources.	• Measure of how well a manufacturing system, operation, or process is utilizing its resources to get the desired results.
• Quantity	• Quality
• Output / Input	• (Achieved output / Expected output) x 100%

Productivity is the output per unit of input.

Efficiency is the comparison of actual output to expected output

Productivity

- Productivity is an important metric in work systems because improving productivity is how worker compensation can be increased without increasing the costs of the products and services they produce. This leads to more products and services at lower prices for consumers.
- The term *process* can refer to an individual production or service operation.
- Labor productivity

$$LPR = \frac{WU}{LH}$$

Productivity

- *LPR* = labor productivity ratio
- *WU* = work units of output
- *LH* = labor hours of input

$$LPR = \frac{WU}{LH}$$

- The definition of output work units (WU) depends on the process under consideration. For example, in the steel industry, tons of steel is the common measure. In the automobile industry, the number of cars produced is the appropriate output measure.
- This measure can be used to compare the labor efficiencies of different companies in a given industry, or to compare the same industries among different nations. Obviously, fewer labor hours are better and mean higher productivity.
- A company or a country that can produce the same output with fewer input labor hours not only has a higher productivity; it also has a competitive advantage in the global economy.

Example

- In a recent month, a car manufacturing company has produced 300 cars with 5,000 total hours of work. The company's productivity ratio for this month can be calculated as follows:

Labor productivity ratio = 300 cars/5,000 hours

Labor productivity ratio = 0.06 car per hour

Example

- A shoe manufacturer has 25 employees in June. During the month of June, each person worked for a total of 8 hours a day, 5 days a week, for 4 weeks. During June, the shoe manufacturer produced 130,456 pairs of shoes. In July, the shoe manufacturer only had 20 employees. This was because 5 employees took a vacation for the month. The remaining 20 employees worked a total of 8 hours a day, 5 days a week, for 4 weeks. In July, the shoe manufacturer produced 112,999 pairs of shoes. In which month were the shoe manufacturer's employees the most productive?
- The labor productivity ratio for each month should be calculated in order to answer this question. Before labor productivity can be calculated, the total man-hours worked in each month need to be determined.

$$\begin{aligned}\text{June Man-hours} &= 25 \text{ employees} \times 8 \text{ hours per day} \times 5 \text{ days per week} \times 4 \text{ weeks} \\ &= 4,000 \text{ Man-hours}\end{aligned}$$

$$-$$

$$\begin{aligned}\text{July Man-hours} &= 20 \text{ employees} \times 8 \text{ hours per day} \times 5 \text{ days per week} \times 4 \text{ weeks} \\ &= 3,200 \text{ Man-hours}\end{aligned}$$

Example cont..

- Now that the total man-hours worked have been determined, the labor productivity ratio can be calculated for each month.

$$\text{June Labor Productivity Ratio} = \frac{130,456 \text{ pairs of shoes}}{4,000 \text{ Man-hours}}$$
$$= 32.614 \text{ pairs of shoes per hour}$$

—

$$\text{July Labor Productivity Ratio} = \frac{112,999 \text{ pairs of shoes}}{3,200 \text{ Man-hours}}$$
$$= 35.312 \text{ pairs of shoes per hour}$$

- So it can be seen that, even though there were 5 fewer employees working in July, Sally Shoe Factory's employees were actually more productive in July than they were in June.

Productivity

- ***Capital*** refers to the substitution of machines for human labor; for example, investing in an automated production machine to replace a manually operated machine. The automated machine can probably operate at a higher production rate, so even if a worker is still needed to monitor the operation, productivity has been increased. If the worker is no longer needed at the machine, then labor productivity has been increased even more. (Capital is generally assets)

- ***Technology*** refers to a fundamental change in the way some activity or function is accomplished. It is more than simply using a machine in place of a human worker. It is using a brand-new type of machine to replace the previous type. (Technology refers to the work method/design)

Productivity

- The distinctions between capital improvements and technology improvements are sometimes subtle, because new technologies almost always require capital investments.
- Arguing about these differences and subtleties is not as important as recognizing that the important gains in productivity are generally made by the introduction of capital and technology in a work process, rather than by attempting to extract more work in less time from workers.
- By investing in capital and technology to increase the rate of output work units and/or reduce input labor hours, the labor productivity ratio is increased.

Productivity

TABLE 7 Examples of Technology Changes that Dramatically Improved Productivity

Old Technology	New Technology	Improvement
Horse-drawn carts	Railroad trains	Substitution of steam power for horse power, use of multiple carts (passenger or freight cars)
Steam locomotive	Diesel locomotive	Substitution of diesel power technology for steam power technology
Telephone operator	Dial phone	Dial technology allowed "clicks" of the dial to be used to operate telephone switching systems
Dial phone	Touch-tone phone	Substitution of tone frequencies in place of "clicks" to operate telephone switching systems for faster dialing
Manually operated milling machine	Numerical control milling machine	Substitution of coded numerical instructions to operate the milling machine rather than a skilled machinist
DC3 passenger airplane (1930s)	Boeing 747 passenger airplane (1980s)	Substitution of jet propulsion for piston engine for higher speed, larger aircraft for more passenger miles

Labor Productivity Ratio Problems

- ***Nonhomogeneous output units***. The output work units are not necessarily homogeneous. For example, using the annual production of automobiles as the output measure does not account for differences in models, vehicle sizes, and prices. An expensive luxury model is likely to require more labor hours of assembly time than an inexpensive compact car.

- ***Multiple input factors***. As previously indicated, labor is not the only input factor in determining productivity. In addition to capital and technology, other input factors may include materials and energy. For example, in the production of aluminum, electric power and the raw material bauxite are much more important than labor as inputs to the process.

Labor Productivity Ratio Problems

- ***Price and cost changes***. The prices of output work units and the costs of input factors (labor, materials, power) change over time, often unpredictably. A company may improve productivity, but if the prices of its products decrease due to market forces, the company could find itself in severe financial difficulty. The steel industry in the United States during the late 1990s and early 2000s provides a perfect example of this case.

- ***Product mix changes***. Product mix refers to the relative proportions of products that a company sells. If the mix of expensive and inexpensive products changes from year to year, an annual comparison based on the labor productivity ratio is less meaningful.

labor Productivity Index

- An alternative productivity measure is the labor productivity index that compares the output/input ratio from one year to the next. The productivity index is defined as follows:

$$LPI = \frac{LPR_t}{LPR_b} * 100$$

- *LPI* = labor productivity index
- *LPRt* = labor productivity ratio during some time period of interest
- *LPRb* = labor productivity ratio during some defined base period

Example

- During the base year in a small steel mill, 326,000 tons of steel were produced using 203,000 labor hours. In the next year, the output was 341,000 tons using 246,000 labor hours. Determine:

(a) the labor productivity ratio for the base year
In the base year, LPR = 326,000/203,000 = 1.606 tons per labor hour.

(b) the labor productivity ratio for the second year
In the second year, LPR = 341,000/246,000 = 1.386 tons per labor hour.

(c) the labor productivity index for the second year.

The productivity index for the second year is LPI = (1.386 /1.606) * 100 = 86.3