

CHAPTER: TWO

PRODUCTIVITY MEASUREMENT

Productivity Measurement

- Productivity measurement indeed is an additional activity but it has numerous benefits.
- One of the Productivity measurement objectives is to promote productivity improvement.
- This improvement means the ability to produce more with the same or less input which results an increase in an overall national income.
- Remember - what is important for productivity is to compare data (how was the situation before and how it is now?) and trends (how slow or fast ,is the situation improving?)

Benefits Of Productivity Measurement

- Productivity measurement enables an enterprise to assess the efficiency of conversion of its resources to goods.
- Based on this assessment, the enterprise would know whether it is doing well or badly and therefore could take the necessary action to produce more goods for a given amount of resources used.
- Measurement enables the enterprise to do resource planning and to set quantifiable objectives of productivity levels at which it ought to be operating.
- also enables an enterprise to know whether it is improving its profitability through productivity or through price recovery.
- enables an enterprise to know the results of management decisions, to monitor progress, and to provide feedback.
- Thus, measurement is integral to the productivity management process.

Basic productivity measurement

- While productivity has been defined differently by different people, still the various definitions and interpretations of productivity could be summarized into the relationship between output and input.
- The choice between them depends on the purpose of productivity measurement and, in many instances, on the availability of data.
- Broadly, productivity measures can be classified as single factor productivity measures (relating a measure of output to a single measure of input) or
- Multifactor productivity measures (relating a measure of output to a bundle of inputs).

- The two basic and commonly used approaches for measuring productivity are as follows:
1. **Partial productivity** is the ratio of output to one class of input.
 - For example, labour productivity (the ratio of output to labour input) is a partial measure.
 - Similarly, material productivity (the ratio of output to material input) and
 - machine productivity (the ratio of output to machine input) are examples of partial productivities.
 2. **Total productivity** is the ratio of total output to the sum of all input factors.
 - Thus, a total productivity measure reflects the joint impact of all inputs in producing the output.
 - It is a kind of a higher level of productivity assessment combining several or many partial productivity measures.

How to measure output and input

- **Outputs** are the finished units or the partially produced (work-in-progress) units by an enterprise.
- They should be tangible or measurable and should meet the quality specifications.
- Outputs are expressed in different units depending on the product, the industry practice or client requirements.
- Outputs and inputs are expressed either in physical (kilograms, metres, hours, etc.) units or in monetary terms.
- Ideally, both should be expressed in uniform physical units. Unfortunately, however, this is seldom the case.
- Thus, monetary values are used
- A reference period (often referred to as "base period") is normally used for calculations, so that data are in constant values.

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- Thus, the value of output is expressed as follows:

$$\begin{array}{|c|} \hline \text{Value of finished} \\ \text{units in any period} \\ \text{(base period)} \\ \hline \end{array} = \begin{array}{|c|} \hline \text{Number of finished} \\ \text{units in base period} \\ \hline \end{array} \times \begin{array}{|c|} \hline \text{Selling price per unit} \\ \text{in the base period} \\ \hline \end{array}$$

- whereas the value of work-in-progress units is expressed as follows:

$$\begin{array}{|c|} \hline \text{Value of partial} \\ \text{units in any} \\ \text{period (base} \\ \text{period)} \\ \hline \end{array} = \begin{array}{|c|} \hline \text{Number of work-} \\ \text{in progress units} \\ \text{in base period} \\ \hline \end{array} \times \begin{array}{|c|} \hline \text{Percent} \\ \text{completion} \\ \hline \end{array} \times \begin{array}{|c|} \hline \text{Selling price} \\ \text{per unit in the} \\ \text{base period} \\ \hline \end{array}$$

- The most common inputs measured are labor, capital, materials, and others categorized as the intermediate factors.
- **Human work input** usually considers the direct labour cost responsible for the production of a particular output.
- In regard to the labor input, the data includes headcount (i.e., persons),
- cost which includes wages and all fringe benefits, and time which is typically collected in terms of hours.
- Indirect labour cost could be taken separately, and another productivity index computed separately as well.
- One could even consider all the human resources employed in producing the output.
- Labour is usually measured in units such as worker-hours, worker-days, worker-months and worker-years.
- When value of human work input is used, then it is computed by:

Value of
worker-hours
for the period

=

Number of
worker-hours

X

Average salary or
wage rate for the
period covered

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- **Material input** consists of all raw materials expressed in physical (kg, metres, bolts, etc.) or monetary units.
- For the material inputs, it is normally collected the data in either the physical unit (e.g., pieces, m2, and m3) or the financial value (e.g., purchased cost).

$$\begin{array}{ccccc} \text{Value of raw material} & & \text{Quantity of material} & & \text{Purchase price of the} \\ \text{consumed in a given} & & \text{used for this product} & & \text{material in the base} \\ \text{period} & = & \text{in this period} & \times & \text{period} \end{array}$$

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- **Capital input.**
- For the capital input, it includes all related physical or tangible assets used to generate the outputs;
- e.g., machinery and equipment/instrument, and land and buildings.
- It is commonly measured in either the physical quantity (e.g. number of machines, equipment hours, and facility space) or the financial value (e.g., depreciation value to production equipment).
- **Energy input.**
- The energy input is the volume or cost of energy incurred for a given period for a given output.
- Energy used for different industries vary, but usually these consist of electricity, natural gas and diesel oil.
- The usual basis for electricity consumption is the periodic electricity bill.

Standard Productivity Indexes

- As mentioned before, there are two commonly used approaches for measuring productivity – partial productivity and total productivity.
- There are three ways to compute partial and total productivity indexes.
- These are:
 - The physical productivity,
 - The value productivity and
 - The value-added productivity methods.
- The main problem here is how to define the outputs, in other words, what are the units of measure for materials, labour, machine, energy, etc.

1. Physical productivity measurement method

- This method uses the quantity of output and input as data for calculating the indexes.
- The main physical productivity indexes are:

$$1. \text{ Labour productivity index} = \frac{\text{volume of output}}{\text{labour input}}$$

$$2. \text{ Material productivity index} = \frac{\text{volume of output}}{\text{volume of material input}}$$

$$3. \text{ Machine productivity index} = \frac{\text{volume of output}}{\text{machine input}}$$

$$4. \text{ Energy productivity index} = \frac{\text{volume of output}}{\text{volume of energy input}}$$

$$5. \text{ Total physical productivity index} = \frac{\text{Total volume of output}}{\text{Total volume of all input}}$$

2. Value Productivity Measurement Method

1. Labour productivity index = $\frac{\text{value of output}}{\text{Value of labour input}}$
2. Material productivity index = $\frac{\text{value of output}}{\text{value of material inputs}}$
3. Machine productivity index = $\frac{\text{value of output}}{\text{value of machine inputs}}$
4. Energy productivity index = $\frac{\text{value of output}}{\text{value of energy inputs}}$
5. Total physical productivity index = $\frac{\text{Total value of output}}{\text{Total value of all inputs}}$

3. Value-added productivity measurement method

- This method uses value-added (expressed in monetary units) as data for calculation,
- Where Value-added = current income (before tax) + personnel expenses + financial costs + rent + tax + depreciation cost
- Data for value-added computation are taken from the financial statement.
- In the absence of a financial statement, small garment enterprises could use physical and value productivity measurement methods.

Labour productivity index = value-added / labour input

Capital productivity index = value-added / capital input

- Warning: Note that an index is a ratio between two quantities; therefore it is a number, with no dimension associated to it

Illustration 2

- ABC garment manufacturing industry has consumed the following inputs in order to produce a jacket for a particular period of time; this company has a daily output of 500 pieces of jacket and the selling price of a one jacket is 400 ETB. to produce one jacket the company consumed a material cost of 200 ETB and 40 machines. The company has 8 hrs of working time per a day, and it has a total of 40 operators with average salary of 10 ETB/Hr. in addition, the company consumed 400 kwh of electricity per day and a single kwh cost 1ETB.
- Based on the information given calculate (using physical and value productivity measurement method)
- Labour productivity index
- Energy productivity index
- Total productivity index

Physical Productivity Measurement Method

- Solution

1. Labour productivity = $\frac{\text{volume of output}}{\text{labour input}}$

$$\text{Labour productivity} = \frac{500 \text{ unites}}{40 \text{ operators}} = 12.5 \text{ unit/person}$$

$$= \frac{500 \text{ unites}}{40 \text{ operators} \times 8 \text{ Hr}} = 1.56 \text{ unit/work- hour}$$

$$\text{This means} = \frac{40 \text{ operators} \times 8 \text{ Hr}}{500 \text{ unites}} = 0.64 \text{ hour}$$

This amount of time is needed to finish one jacket

- Note: Machine-hours used are assumed to be equal to worker-hours, thus machine productivity will have the same index as labour productivity.

2. Energy productivity

$$\text{Energy productivity index} = \frac{\text{volume of output}}{\text{volume of energy inputs}}$$

$$\text{Energy productivity} = \frac{500 \text{ units}}{400 \text{ Kwh}} = 1.25 \text{ units/Kwh}$$

➤ This means 0.8Kwh of electricity is consumed to produce a single jacket.

- Given that there are 40 machines in the enterprise, the daily cost of electricity per machine is:
- $400 \text{ Kwh} / 40 \text{ machines} = 10 \text{ Kwh/machine}$

Value Productivity Measurement Method

$$1. \text{ Labour productivity} = \frac{\text{value of output}}{\text{value of labour input}}$$

Labour productivity =;

$$= \frac{500 \text{ unites} * 400_{ETB}}{40 \text{ operators} * 8hr * 10_{ETB}} = 62.5_{ETB}$$

✓ This means that for every monetary unit of labour, 62.5 ETB of revenue is generated.

$$2. \text{ Energy productivity index} = \frac{\text{value of output}}{\text{value of energy inputs}}$$

$$\text{➤ Energy productivity} = \frac{500 \text{ unites} * 400_{ETB}}{400KWH * 1_{ETB}} = 500_{ETB}$$

➤ This means that for every monetary unit of energy, 500 ETB of revenue is generated.

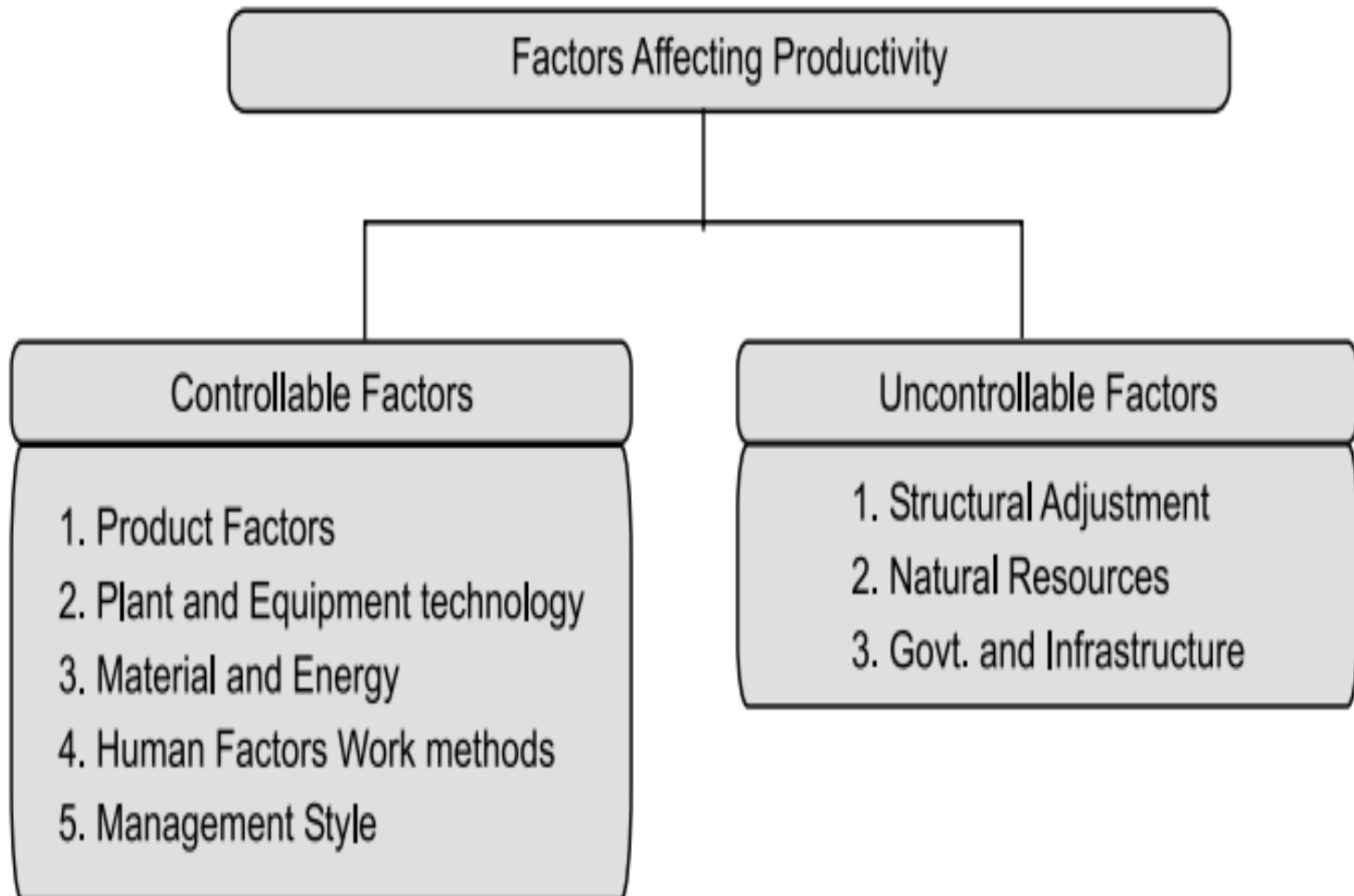
Total productivity

- Total productivity = $\frac{\text{value of total output}}{\text{value of total input}}$
- For the time being we are calculating total productivity based on labour and energy productivity thus;

$$\text{Total productivity} = \frac{\text{value of total output}}{\text{value of (labour + energy) input}}$$

$$\text{Total productivity} = \frac{500 \text{ units} * 400 \text{ ETB}}{40 \text{ workers} * 8 \text{ hr} * 10 + 400 \text{ KWH} * 1 \text{ ETB}} = 55.56$$

Factors Affecting Productivity



- Factors influencing productivity can be classified broadly into two categories: controllable (or internal) factors and un-controllable (or external) factors.

(A) CONTROLLABLE (OR INTERNAL) FACTORS

1. Product factor:

- In terms of productivity means the extent to which the product meets output requirements product is judged by its usefulness.
- The cost benefit factor of a product can be enhanced by increasing the benefit at the same cost or by reducing cost for the same benefit.
- Production volume

2. Plant and equipment:

- These play a prominent role in enhancing the productivity.
- The increased availability of the plant through proper maintenance and reduction of idle time increases the productivity.
- Productivity can be increased by paying proper attention to utilization, age, modernization, cost, investments etc.
- CNC machines
- Computer aided manufacturing (CAM)

Technology

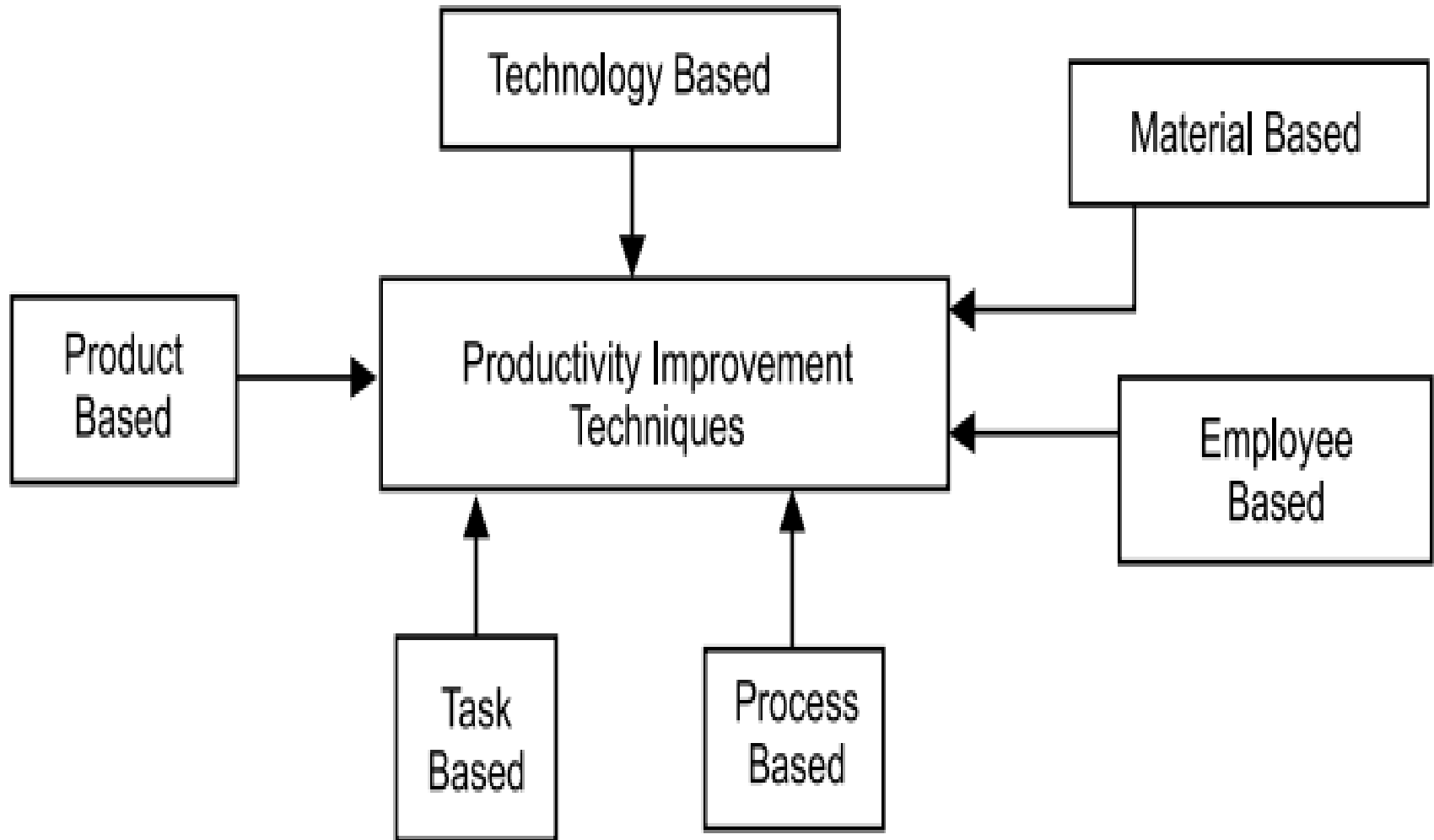
- Innovative and latest technology improves productivity to a greater extent.
- Automation and information technology helps to achieve improvements in material handling, storage, communication system and quality control.
- The various aspects of technology factors to be considered are:
 - (i) Size and capacity of the plant,
 - (ii) Timely supply and quality of inputs,
 - (iii) Production planning and control,
 - (iv) Repairs and maintenance,
 - (v) Waste reduction, and
 - (vi) Efficient material handling system.

- **Material and energy:** Efforts to reduce materials and energy consumption brings about considerable improvement in productivity.
 1. Selection of quality material and right material.
 2. Control of wastage and scrap.
 3. Effective stock control.
 4. Development of sources of supply.
 5. Optimum energy utilization and energy savings.
- **Human factors:** Productivity is basically dependent upon human competence and skill.
- The general level of education
- Use of computers and other sophisticated equipment by employees
- Ability to work effectively is governed by various factors such as education, training, experience aptitude etc., of the employees.
- Motivation of employees will influence productivity.
- **Work methods:** Improving the ways in which the work is done (methods) improves productivity, work study and industrial engineering techniques and training are the areas which improve the work methods, which in term enhances the productivity.
- **Management style:** This influence the organizational design, communication in organization, policy and procedures.
- A flexible and dynamic management style is a better approach to achieve higher productivity.

(B) UN-CONTROLLABLE (OR EXTERNAL) FACTORS

- **Structural adjustments:** Structural adjustments include both economic and social changes.
- **Economic changes** that influence significantly are:
 - (a) Shift in employment from agriculture to manufacturing industry,
 - (b) Import of technology, and
 - (c) Industrial competitiveness.
- **Social changes** such as women's participation in the labour force, education, cultural values, attitudes are some of the factors that play a significant role in the improvement of productivity.
- **Natural resources:** Manpower, land and raw materials are vital to the productivity improvement.
- **Government and infrastructure:**
- Government policies and programmes are significant to productivity practices of government agencies, transport and communication power, fiscal policies (interest rates, taxes) influence productivity to the greater extent.
- An excessive amount of government regulation may have a detrimental effect on productivity

Productivity Improvement Techniques



1. TECHNOLOGY BASED

- **Computer Aided Design (CAD)**
- **Computer Aided Manufacturing (CAM)**
- **CAD** refers to design of products, processes or systems with the help of computers. The impact of
- CAD on human productivity is significant for the advantages of CAD are:
 - (a) Speed of evaluation of alternative designs,
 - (b) Minimization of risk of functioning, and
 - (c) Error reduction.
- **CAM** is very much useful to design and control the manufacturing.
- It helps to achieve the effectiveness in production system by line balancing.
 - (a) Production Planning and Control
 - (b) Capacity Requirements Planning (CRP), Manufacturing Resources Planning (MRP II) and Materials Requirement Planning (MRP)
 - (c) Automated Inspection.

Computer Integrated Manufacturing Systems (CIMS)

- Computer integrated manufacturing: Computer integrated manufacturing is characterized by automatic line balancing, machine loading (scheduling and sequencing), automatic inventory control and inspection.
 1. Robotics
 2. Laser technology
 3. Modern maintenance techniques
 4. Energy technology
 5. Flexible Manufacturing System (FMS)

- **(B) EMPLOYEE BASED**

1. Financial and non-financial incentives at individual and group level.
2. Employee promotion.
3. Job design, job enlargement, job enrichment and job rotation.
4. Worker participation in decision-making
5. Quality Circles (QC), Small Group Activities (SGA)
6. Personal development.

- **(C) MATERIAL BASED**

1. Material planning and control
2. Purchasing, logistics
3. Material storage and retrieval
4. Source selection and procurement of quality material
5. Waste elimination.

(D) PROCESS BASED

1. Methods engineering and work simplification
2. Job design evaluation, job safety
3. Human factors engineering.

(E) PRODUCT BASED

1. Value analysis and value engineering
2. Product diversification
3. Standardization and simplification
4. Reliability engineering
5. Product mix and promotion.

(F) TASK BASED

1. Management style
2. Communication in the organization
3. Work culture
4. Motivation
5. Promotion group activity