Chapter 3

# The concepts of productivity

## 3.1 Introduction

Productivity is an age old axiom for the measure of the efficiency of a person, machine, factory, system, etc., in converting inputs into useful outputs. Since work study generally is referred to as the tool to increase productivity, it is imperative to understand more of productivity in industrial and other situations before our going into the details of work study. This chapter as well as the next one, hence attempt to create an appreciation of the role played by work study in achieving the goal of increased productivity.

As the topic suggests, modernization and innovation or the development of new products and processes may be some of ways to increase productivity, but the developing countries with their difficult foreign exchange situation cannot afford to think of modernizing the industrial system, by importing know how for the new products or processes. In short, we cannot afford that type of innovation that necessitates larger inflow of inputs. What is needed today is that aspect of innovation, that improves the functional design of a product or simplifies the method of operation, so that with the least increase in inputs, the output is considerably raised, thereby increasing the operational efficiency. This point can be better understood by Fig. 3.1.

This exactly what work study does. As we have seen in the previous chapter the term work study is not new to industry sector. One of its wings, viz., time study has long been used as a tool to set up targets, thereby maintaining productivity. But this aspect has been overemphasized in the industry, and as a result the impression we get of work study has been a function of the stopwatch time study man, who is generally eyed with suspicion by the labor as a management agent to set targets and reduce their wages, this has resulted in a complete lack of appreciation of the benefits of the other wing of work study, viz., method study or work simplification, which by means of its systematic investigation and critical examination techniques, aims at increasing productivity with little inflow of inputs. This fact that the continuous improvement or what the Japanese call as Kaizen, can achieve higher cost reduction than what could be achieved by expensive innovations, is further discussed in Chapter 11 on kaizen.

As an attempt to promote the full-fledged practice of work study, the following paragraphs present an anatomy of productivity, highlighting work

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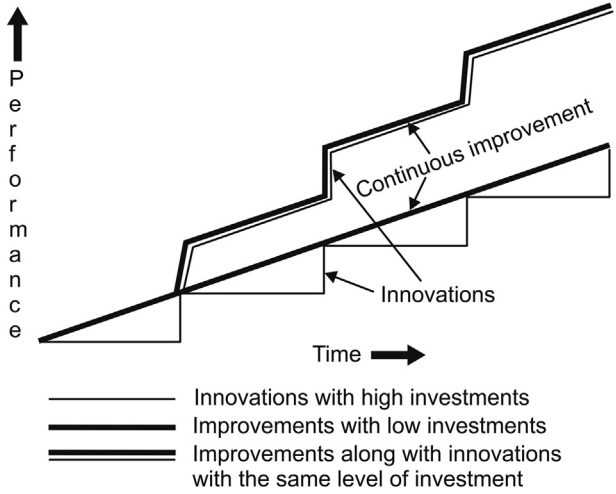


**FIGURE 3.1** Improvement vs. innovation.

$$\text{PRODUCTIVITY} = \frac{\text{OUTPUT}}{\text{INPUT}}$$

**FIGURE 3.2** The productivity formula.

study as the most significant and practical management tool available to the industrial manager in achieving higher productivity.

## 3.2 The concept of productivity

Productivity is related to the goods and services produced in relation to the resources utilized in producing the same. In a broad sense, it is the ratio between the output of a certain process and the input of the resources employed. We can express this in a simple formula Fig. 3.2.

## 3.3 Some definitions of productivity

I.L.O. in one of its publications, *Higher Productivity in the manufacturing industries* defined Productivity as the ratio between the output of wealth and wealth input of resources used in the process of production.

Some of other more specific explanations offered on productivity are:

*Productivity is an attitude of mind; it is the mentality of the progress of the constant improvement of that which exists. It is the certainty of being able to do things better today than yesterday and continuously. It is the constant adaptation of economic and social life to the changing conditions. It is the continual*

*effort to apply new techniques and methods. It is the faith in the human progress.*

European Productivity Agency (EPA).

*In the widest sense, it may be said that productivity is the measurement of the economic standards of the means.*

The organization for European Economic Cooperation (OEEC).

*Productivity is a measure of the efficiency of a person, machine, factory, system, etc., in converting inputs into useful outputs. Productivity is a critical determinant of cost efficiency.*

Business Dictionary.

*Productivity is an average measure of the efficiency of production expressed as the ratio of output to inputs used in the production process.*

Wikipedia.

*Productivity is an economic measure of output per unit of input. Inputs include labor and capital, while output is typically measured in revenues and other GDP components such as business inventories.*

Investopedia.

*Productivity is the rate per unit area or per unit volume at which biomass consumed as food by other organisms is made by producers.*

Webster Dictionary.

*Productivity is the rate at which a company or country makes goods, usually judged in connection with the number of people and the amount of materials necessary to produce the goods.*

Cambridge Dictionary.

In spite of providing such endless chain of explanations and explanatory definitions for productivity, the simplest definition is still as given earlier, viz., the ratio of output to input.

In other words, productivity would mean

| | |
|---|---|
| **for the nation** | The output of goods and services needed by the community by optimal use of resources like materials, equipment and manpower available. |

| | |
|---|---|
| **for the industry** | The output of products with the optimal use of the capital assets, materials and services of employees. |
| **for individuals** | Saleable value of the work achieved in return for the use of individual resources and those provided for personal use. |

Even though productivity is referred to as the input-output ratio in the above definitions, it is in effect the process of harnessing the capacity to increase the outputs by optimal utilization of all the resources employed at the most economical cost of production.

## 3.4 Productivity vs. production

We should not confuse productivity with production, which is merely the quantum of output irrespective of the resources used up. For example, a certain forge shop has 10 forging machines, if the output of each machine is 100 pieces per shift, then the total production or output for the shop is 1000 pieces per shift. In general, the words output and production are synonymous.

We can increase the production by merely increasing the resources without consideration to the cost. For example, the production of the forging shop cited above can be increased from 1000 pieces per shift to 1500 per shift, by merely increasing the number of machines from 10 to 15. But this increase in production need not necessarily increase the productivity, which is the output for each input resource that is the output of each machine, which continues to remain the same at 100 pieces per machine per shift. The distinction is more explained by the following illustrations.

*Example: If 100 men of group A can lay 5 km of road per week, and if 150 men of group B can lay 6 km similar road per week, whose productivity is higher?*
Productivity of group A = 5 km/100 = 50 m per man per week.
Productivity of group B = 6 km/150 = 40 m per man per week.
Hence the productivity of group A is higher than that of group B
*Example: The total production per shift of group A of 20 wood screw making machines is 6000 gross, while the production of group B of similar machines numbering 30, is 7500 gross. Whose productivity is higher?*
Productivity of group A = 6000/20 = 300 gross per shift per machine.
Productivity of group B = 7500/30 = 250 gross per shift per machine.
Hence, we can say that the productivity of the first group of machines is thus higher than that of the second group.

## 3.5 The input-output concept

This concept of productivity as the ratio of the output of the inputs, is applicable in any situation, involving a conversion process, whether it is a

manufacturing industry or agriculture or trading or even an educational institution. In view of its significance, this concept is dealt more in detail in Chapter 5.

## 3.6 Connotations of productivity

Apart from the above meaning of productivity, we can also connote the following terms related to productivity

- Physical Productivity, which is the ratio of the quantum produced with the resources consumed (usually labor effort in terms of man-hours, days, or months).
- Functional Productivity, which is a ratio of the amount of the functionality delivered or value added to the resources or effort consumed. Functionality may be measured by use cases, requirements, features, or functions, as further discussed in Chapter 18 on Value Analysis.
- Economic Productivity, which is a ratio of the value of the product produced for the cost of the resources used to produce it. It helps to evaluate the economic efficiency of an organization.

It may be noted that while understanding economic productivity is essential in making good decisions about outsourcing and subcontracting, it alone is not used to predict project costs since the outcome can be affected by many factors outside the control of the project, like sales volume, inflation, interest rates, substitutions in resources or materials etc., as well as all the other factors that affect physical and functional measures of productivity.

## 3.7 The measure of productivity

The measure of the term Productivity varies due to differences in technology, differences in the efficiency in the production process and the differences in the environment in which the production unit operates.

There are various productivity measures depending upon the purpose of productivity measurement and, in general, on the availability of the data. As explained below, the measures can also relate gross output to one or several inputs and those which use a value-added concept to capture movement of output.

We can classify these measures into 2 broad groups

- Single factor productivity measures (relating to measures of output to a single measure of input)
- Multifactor productivity measures (relating a measure of output to a bundle of inputs).

As explained above, the unit we used for measuring productivity as seen from earlier paragraphs, can either be in terms of output per man per unit time or output per machine per unit time or in other words, the output per

man hour or machine hour. But in actual practice, there can be hundreds of such units in which productivity can be expressed, depending upon the situation. In such cases only a single input is considered. For example, in our previous example on the road laying in paragraph 3.4, we expressed the productivity in meters per man per shift, that is, we considered only the human input, whereas there could be other inputs in the form of material, tar, etc. Again in comparing the performances of different cars, we compare the fuel productivity or the fuel efficiency of the vehicle in km per liter (kpl), since fuel is the major input.

Obviously, to get an absolute measure of productivity, we need to express both the inputs and outputs in the same units. One of the most convenient ways of doing this is to assign a money value to each input and output. That is, productivity can be expressed as the ratio of the total value of the outputs of the total cost of the inputs as already expressed in Fig. 3.2.

Or

Where

Tp = Total Productivity
To = Total Output
Ti = Sum of all inputs

We can also estimate the productivity of each input separately and this is called the partial productivity.

## 3.8 Other measures of productivity

As illustrated in the earlier paragraphs, the following indices can be cited as the other partial measures of productivity based on individual inputs measured in money units.

$$\text{Labor Productivity} = \frac{\text{Total output}}{\text{Labor input}}$$

$$\text{Material Productivity} = \frac{\text{Total output}}{\text{Material input}}$$

$$\text{Energy Productivity} = \frac{\text{Total output}}{\text{Energy input}}$$

Total Productivity measure (TPM) or Total Factor Productivity is the ratio of the total tangible outputs of all products and services to the total tangible resource inputs

$$\text{TPM} = \frac{\text{Total tangible outputs}}{\text{Total tangible inputs}}$$

Where,

Total tangible output = Value of finished goods produced, value of partial goods produced + inventory + dividends from securities + interest + other income in money units and
Total tangible input = Value of labor + capital + material + energy and other expenses in money units.

Since the value of the money keeps varying year by year due to inflation, etc., the productivity is generally adjusted to the base year by a factor called the factor of deflation, which is expressed as the ratio of the current year price index to that of the base year.

$$\text{Factor of deflation} = \frac{\text{Current year price index}}{\text{Base year price index}}$$

## 3.9 Levels of productivity measurement

Depending upon the specific application of the productivity measurement, we can formulate these in 5 basic levels, as illustrated in the Table 3.1.

**TABLE 3.1** Levels of productivity measurement.

| Sl. no | Level | Measure | Application |
|---|---|---|---|
| 1 | International | Productivity indices from different countries | Compare the growth and competitive position among nations |
| 2 | National | Develop economic indicators | Enable the country to plan its resources on a national basis |
| 3 | Sectorial | Indices from different companies of this sector | 1. Compare the performance of sector members for healthy competition<br>2. Plan their manpower requirement |
| 4 | Company | All productivity measures per para 3.7 | Set up goals and plan the future requirement. |
| 5 | Individual | Develop performance measures | 1. Compare index of each resource like performance and bonus earning<br>2. Self-improvement in these performances. |

## 3.10 The concept of increase in productivity

Nevertheless, even the above expression invariably becomes difficult in many cases due to the fact that the inputs in all cases cannot be expressed in rupee value. This is more so in view of the complexity and variety of inputs and outputs.

Hence productivity is better understood by the concept of percentage increase in productivity. That is, we can compare the productivity of a certain resource or input before and after effecting, a change or improvement,

For example, if we can increase the produce of agricultural land from 1 tonne to 1.5 tonnes per acre by better farming methods like irrigation and fertilizers, without incurring much increase of capital expenditure, the productivity of the land is said to have increased by 50%.

Similarly, if an operator is able to increase his output from 100 pieces per Shift to 120 pieces by simplified methods, his productivity is said to have increased by 20%.

## 3.11 Factors that drive productivity growth

We can identify five Factors that Drive productivity growth as illustrated below

- Investment is in physical capital like machinery, equipment and buildings. It is believed that the availability of more capital enables production of more and better quality output.
- Innovation, metamorphosing of new ideas into new technologies, new products, etc. which can enable working faster and more efficiently to boost productivity.
- Skills, defined as the quantity and quality of labor needed to take advantage of the above investments and innovations.
- Enterprise, which enables seizing of new business opportunities by both start-ups and existing firms by new ideas and technologies.
- Competition improves productivity by creating incentives to innovate and ensures that resources are allocated to the most efficient firms. It also forces existing firms to organize work more effectively through imitations of organizational structures and technology.

## 3.12 How to increase productivity?

Returning to our basic formula on productivity viz, we can compare it with the simple arithmetic expression of

We know that A can be increased in any of the following manners:

**(a)** increase the numerator with no change in the denominator,
**(b)** decrease the denominator with no change in the numerator,
**(c)** increase the numerator substantially with marginal increase in the denominator,

**(d)** decrease the denominator substantially, with marginal reduction in the numerator, or
**(e)** increase the numerator, while decreasing the denominator.

We can adapt these principles to increase productivity by equating the numerator to output and the denominator to input.

1. ***Increasing the output for the same input:*** If the output of a machine is increased from 200 pieces per shift to 220 pieces per shift, without changing any input, the productivity is said to have increased by 10%.
2. ***Reducing the input for the same output:*** If the input of certain process is reduced by 20% without affecting the output, then the productivity is said to have increased by 25%.
3. ***Increasing the output with marginal increase in the input:*** In practice, this is the most popular method of increasing productivity. If the output of a certain operation is increased by 25% after providing a certain fixture which increases the machine cost by 10%, then the productivity is said to have increased by 13.63%.

   Fig. 3.3 below illustrates a case study for this increase in productivity. In a press shop, the weight of the steel strip required for the production

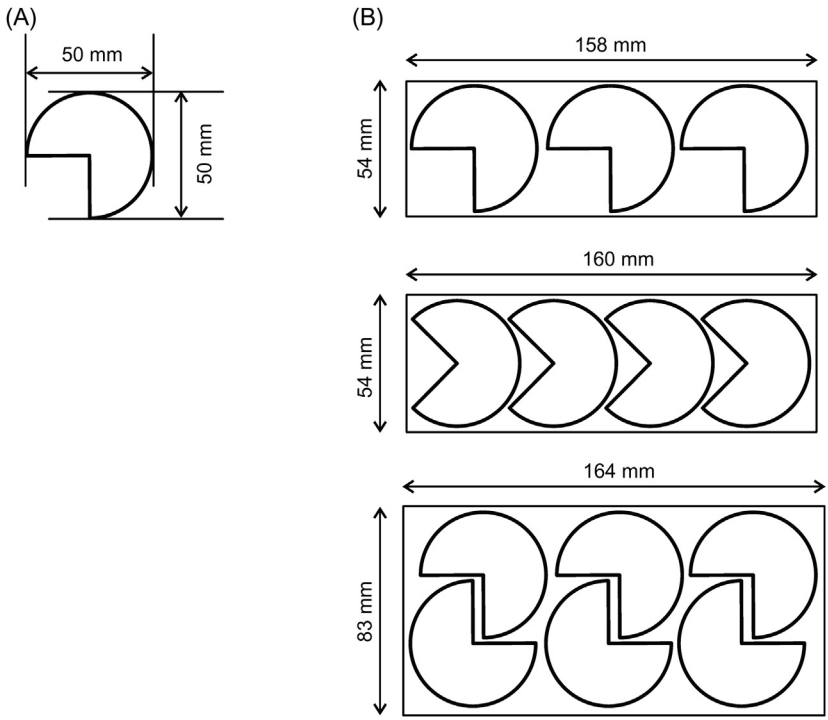


**FIGURE 3.3** Illustration of reduction of input.

**TABLE 3.2** Strip area for the production of the blank.

| No. | Alternative | Feed (mm) | Strip width (mm) | Strip length per 1000 pcs (m) | Strip area per 1000 pcs ($m^2$) | Percentage reduction of scrap |
|---|---|---|---|---|---|---|
| 1 | A | 52.0 | 54 | 158/ 3 = 52.7 | 2.848 | – |
| 2 | B | 37.8 | 54 | 160/ 4 = 40 | 2.160 | 24.1% |
| 3 | C | 54.0 | 83 | 164/ 6 = 27.3 | 2.265 | 20.5% |

of a certain blank, is reduced from 20 kg per 1000 blanks to 16 kg per 1000 blanks, as illustrated in Fig. 3.3. Also the output is doubled by increasing the die cost by 20% (Table 3.2).

In the third case, the productivity is said to have increased by

**Example:** The output of a certain drilling machine is 60 pieces per hour. By providing a certain jig, which has increased the input costs by 10%, the output for the same operation has increased to 90 pieces per hour. Calculate the increase in productivity.

Hence Percentage increase in productivity

4. ***Reducing the inputs considerably at a marginal loss of output:*** In a certain machine shop an effective preventive maintenance program has been introduced. By this, the total operation and maintenance cost of the machine shop is reduced by 20%. Nevertheless, this preventive maintenance program needed regular stoppages of the machine, reducing the total output by 5%. Here despite the reduction in output, the productivity is said to have increased by
5. ***Increasing the output with reduced inputs:*** This yields a two way benefit and is the most preferred form of increasing productivity, though it is less practical.

**Example:** On a certain machining operation, a methods program has been carried out, resulting in a 20% increase in the output of the operator. It also reduced the input costs by 5%. The productivity in this example is said to have increased by

## 3.13 Stewart's 12 step productivity improvement strategy

W.T. Stewart, in 1978, proposed a 12-step productivity improvement strategy for organizations based on a systems perspective. Though simple,

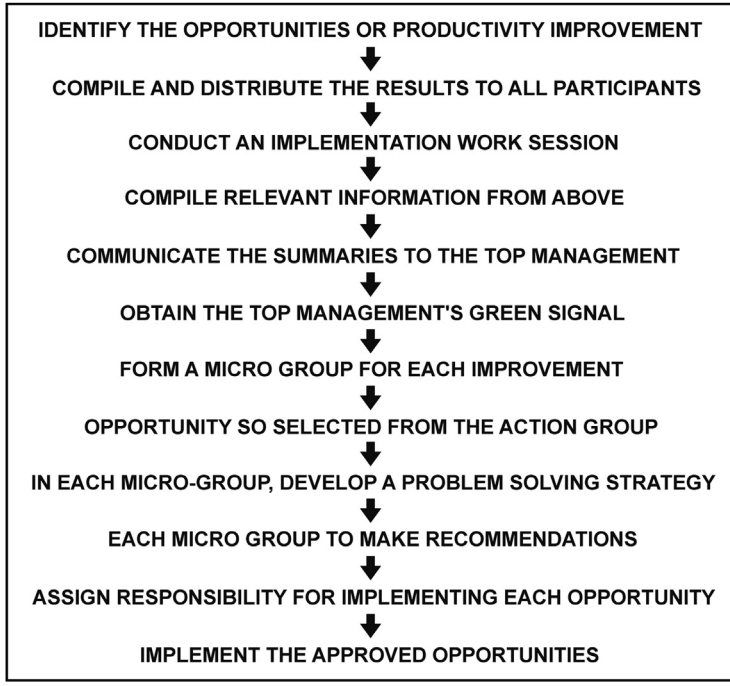


**FIGURE 3.4** Stewart's productivity improvement strategy.

straight forward and common sense oriented procedure, this is applicable to any recommendation and has come to be known as Stewart's strategy, as illustrated in Fig. 3.4.

Subsequently, in 1979 Aggarwal and later other authors proposed the following modified 11-step procedure for productivity improvement, per Fig. 3.5.

## 3.14 Sumant et al.'s productivity improvement techniques

In 1990 David Sumant, Vincent Omachinu and Mario Beruvides of Miami University categorized the several techniques of productivity improvement into 5 basic groups as follows

1. **Technology based techniques**
   - **(i)** Computer Aided design (CAD)
   - **(ii)** Computer Aided manufacturing (CAM)
   - **(iii)** Integrated CAM
   - **(iv)** Robotics
   - **(v)** Laser Beam Technology
   - **(vi)** Group technology
   - **(vii)** Computer graphics
   - **(viii)** Emulation

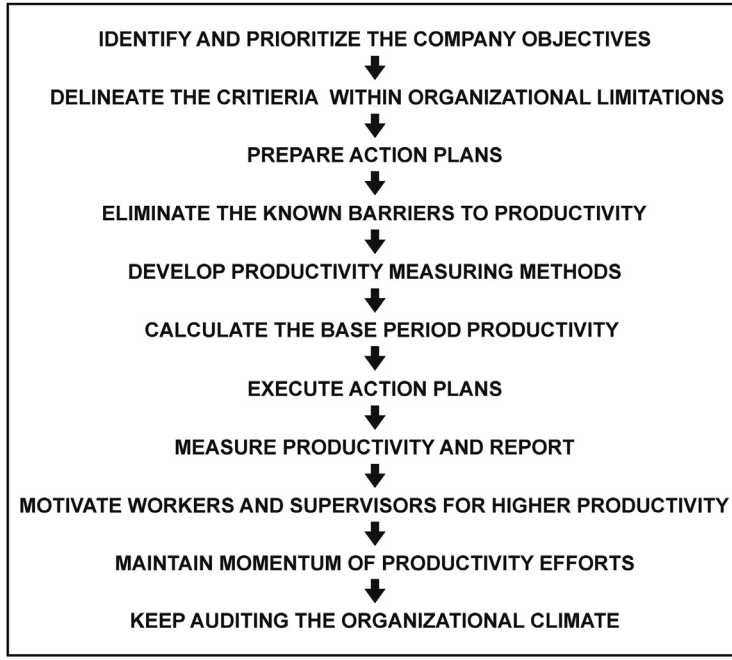


**FIGURE 3.5** Modified productivity improvement strategy.

- **(ix)** Maintenance management
- **(x)** Energy conservation

2. **Employee based techniques**
   - **(i)** Individual financial incentives
   - **(ii)** Group financial incentives
   - **(iii)** Fringe benefits
   - **(iv)** Employee promotions
   - **(v)** Rewarding
   - **(vi)** Job enrichment
   - **(vii)** Job enlargement
   - **(viii)** Job rotation
   - **(ix)** Worker participation
   - **(x)** Skill enhancement
   - **(xi)** Management by objectives
   - **(xii)** Learning curve
   - **(xiii)** Communications
3. **Product based techniques**
   - **(i)** Value engineering
   - **(ii)** Product diversification
   - **(iii)** Product simplification
   - **(iv)** Product standardization

(v) Research and development
(vi) Product reliability improvement
(vii) Advertising and promotion

4. **Task based techniques**
   (i) Methods engineering
   (ii) Work measurement
   (iii) Job design
   (iv) Job evaluation
   (v) Job safety design
   (vi) Ergonomics
   (vii) Job hazard analysis
   (viii) Production scheduling
   (ix) Computer aided data processing
5. **Material based techniques**
   (i) Inventory control
   (ii) Material management
   (iii) Material requirement planning
   (iv) Quality control
   (v) Material handling systems
   (vi) Material reuse and planning
   (vii) Material layout planning

In a nutshell, as suggested in Chapter 11 on Kaizen, the terms Kaizen, CREW et al can be cited as synonyms for method study except minor variations in conceptual application.

## 3.15 The benefits of higher productivity

A meeting convened by I.L.O. of the experts on Productivity in Manufacturing Industries in 1952, summed up the benefits of productivity as follows in its proceedings:

- Larger supplies of both consumer goods and of capital goods at lower costs and lower prices,
- Higher real earnings,
- Improvements in working and living conditions, including shorter working hours,
- In general the strengthening of the economic foundation of the human well being.

We can also cite the following other benefits by way of increased productivity.

**A. To the operatives**

- Higher productivity means higher wages, especially for the piece rated workers and higher bonus to all workers,

- More job security and job satisfaction,
- Boosted up morale and healthier industrial relations,
- Happier domestic life

**B. To the company**

- More profits due to reduced costs of production,
- Increased production volume and increased sales returns,
- Higher and continuous production, reducing the sales price and increasing better customer satisfaction,
- Better industrial relations and hence smoother management,
- Improvement in public image, resulting in higher benefits and name.

**C. To the nation**

- Higher profits earned by the firm would bring in higher tax revenues,
- Export trade is developed, bringing in more foreign exchange,
- Industrial relations would improve, providing healthy examples for other communities,
- Increased overall standard of living, and the consequent prosperity of the nation,
- Higher productivity in some companies induces the less productive companies to improve for their own survival.

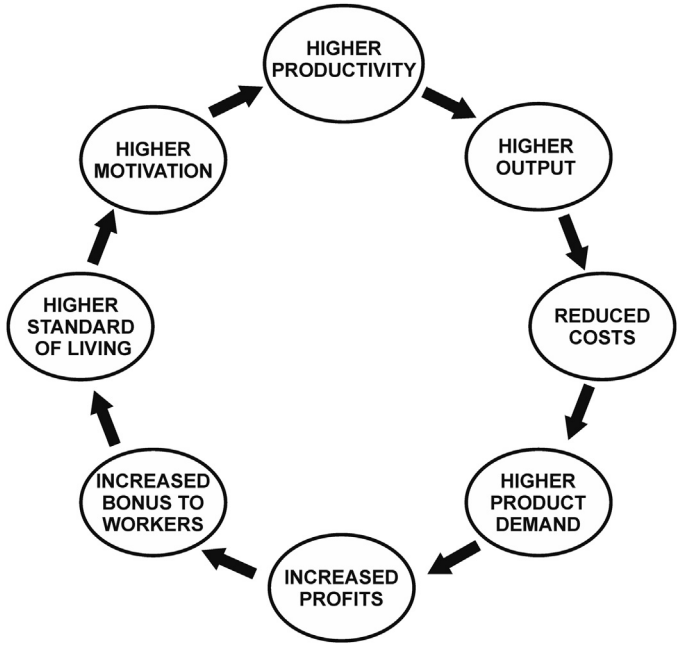


**FIGURE 3.6** Chain reaction of increased productivity.

## 3.16 Productivity and standard of living

Since a country has limited resources, any increase in its productivity goes in a long way to help it to produce more goods thereby improving the general standards of living. Presuming that all other factors like inflation rate are in comparable terms, this statement can be explained by the Fig. 3.6, which depicts the chain reaction of higher productivity.

## 3.17 Conclusion

As rightly highlighted by I.L.O., higher productivity not only generates higher profitability to the organizations, it enables improvements in working and living conditions, including shorter working hours to the workforce, strengthening their economic well-being.

**Criteria questions**

1. Distinguish between innovations and improvements. (3.1)
2. How do you define and distinguish between Production and productivity? (3.3, 3.4)
3. Distinguish between Physical Productivity and Functional Productivity. (3.16)
4. Explain some of the measures of productivity. (3.8)
5. What is the meaning of Total tangible output? (3.8)
6. What factors drive productivity growth? (3.9)
7. Illustrate Increasing the output with marginal increase in the input. (3.12)
8. Discuss Stewart's 12 step productivity improvement strategy. (3.13)
9. Explain some of the benefits of Higher Productivity to the operatives. (3.15)
10. Justify the statement "Productivity and standard of living". (3.6)

## Further reading


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