

*Vocational Higher Secondary
Education (VHSE)*

Second Year

MANAGEMENT

Reference Book



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LIST OF CONTRIBUTORS

Participants

Azeez M

Govt VHSS, Cherppulassery, Palakkad

Nixon C. K.

Govt VHSS, Pakalkuri, Thiruvananthapuram.

Sivaprasad G.

VMBS Govt. VHSS, Thalayolapparambu, Kottayam

Sunny T. J.

NIVHSS, Marampalli, Aluva, Ernakulam

Ravisankar V.S.

VHSS for Girls, Thiruvallam, Thiruvananthapuram

Experts

Dr. Simon Thattil

Prof. of Commerce

School of Business Management and Legal Studies

University of Kerala

Sri. Sujan Kumar K.G.

Asst. Professor of Commerce, Govt. College, Kottayam

Academic Co-ordinator

Dr. Jayalekshmi. S

Asst. Professor, SCERT

State Council of Educational Research and Training (SCERT)

Poojappura, Thiruvananthapuram 695012, Kerala

Website : www.scertkerala.gov.in, e-mail : scertkerala@gmail.com

Phone : 0471 - 2341883, Fax : 0471 - 2341869

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FOREWORD

Dear learners,

The world of business is rapidly changing. New values and management approaches are appearing, organisations are changing their forms and practices, jobs are being redefined and relocated; information technology and intricacies of globalisation are presenting major organisational and economic challenges before the world of business. Trained managers and manpower are needed to tide over this pressure. The efforts in this direction should be initiated from higher secondary level.

In continuation with changes made in the first year, Management in the second year opens with an introduction to economic environment for managerial decision making and moves to short term and long term financial decision making, functional areas of management like production and operations management. Quality management, a recent development in this field is also included. As the thrust is given to managerial decision making, some areas from Statistics like averages, dispersion, correlation and index numbers which are inevitable tools for decision making are included.

This reference book is the result of new approach in designing the course so as to provide an integrated learning model to the learners. Sincere efforts have been taken to make the content simple, comprehensive and self-exploratory. Self-evaluation and term evaluation questions have been included to help the learner to know the progress of learning. Extended activities are also included to enhance management skills. There is ample opportunity for the learners for self-reflection, critical thinking and active learning by exposing themselves to practical business situations.

Hope that the material will make your learning a delightful, interesting and rewarding. Suggestions for improvement are always welcome.

With regards,

Dr. P A. Fathima
Director
SCERT, Kerala

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ABOUT THE SUBJECT

Management is a developing discipline. It ensures the accomplishment of the objectives of an organization within a set of constraints in scientific manner. Being the budding entrepreneurs, vocational higher secondary learners get ample knowledge, skills and attitudes on various aspects of management. The subject Management is introduced in VHSE as part of the commerce education in all commerce based vocational courses. It helps learners to acquaint with different management concepts and their application in business. Learners are also being introduced to certain tools for managerial decisions making from Economics and Statistics.

Learners have acquired the basic concepts of management, its process, functions, objectives and its functional areas, recent trends and certain tools from economics and statistics, used in managerial decision making, during first year. In the second year, as a continuation of what they have studied, the economic environment for managerial decision making and the areas of short term and long term financial decision making, functional areas of management like production and operations management and quality management are included. More areas from Statistics like averages, dispersion, correlation and index numbers which are inevitable tools for managerial decision making are also included in the syllabus.

SYLLABUS

Unit I ECONOMIC ENVIRONMENT FOR MANAGEMENT (26 Periods)

- 1.1. Economic environment – Meaning and Significance
- 1.2. Basic concepts in Economic Environment
 - 1.2.1. National Income: Gross Domestic Product, Net Domestic Product, Gross National Product, Net National Product
 - 1.2.1.1. Methods of Measuring National Income
 - Value Added Method
 - Income Method
 - Expenditure Method
 - 1.2.1.2. Problems in the calculation of National Income
 - 1.2.2. Business Cycle - Phases of Business Cycle

Unit II WORKING CAPITAL MANAGEMENT (22Periods)

- 2.1 Meaning and Concept of Working Capital
- 2.2 Components of Working Capital
- 2.3 Types of Working Capital
- 2.4 Meaning and significance of working capital management
- 2.5 Approaches to working capital Management

Unit III LONG RUN INVESTMENT DECISION - CAPITAL BUDGETING

(24 Periods)

- 3.1. Meaning and Importance of Capital Budgeting
- 3.2. Capital Budgeting Process
- 3.3. Methods of Capital Budgeting – Traditional (Non- Discounted Cash Flow Methods)
 - 3.3.1. Pay Back Method
 - 3.3.2. Average Rate of Return Method
- 3.4. Methods of Capital Budgeting – Discounted Cash Flow Methods
 - 3.4.1. Net Present Value Method
 - 3.4.2. Profitability Index Method
 - 3.4.3. Internal Rate of Return Method

Unit IV PRODUCTION AND OPERATIONS MANAGEMENT (22 Periods)

- 4.1. Meaning and Importance of Production and Operations Management.
- 4.2. Difference between Production and Operation
- 4.3. Major Decisions of Production Management
- 4.4. Plant Location and factors affecting plant location

- 4.5. Plant Layout and different types of Plant Layouts
- 4.6. Aggregate Planning – Meaning, Importance and Strategies
- 4.7. Master Production Scheduling - Meaning, Significance and Development of Master Production Schedule (MPS)

Unit V QUALITY MANAGEMENT (16 Periods)

- 5.1. Meaning and Definition of Quality
- 5.2. Dimensions of Quality – Product and Service
- 5.3. Meaning and Concept of Quality Management
- 5.4. Principles of Quality Management
- 5.3. Quality Systems
 - 5.3.1. Elements
 - 5.3.2. ISO 9000:2000

Unit VI MEASURES OF CENTRAL TENDENCY (32 Periods)

- 6.1. Meaning and Significance of Central Tendency
- 6.2. Qualities of a good average
- 6.3. Types of Average
- 6.4. Simple Arithmetic Mean – Individual Observation, Discrete Series, Continuous Series.
- 6.5. Weighted Arithmetic Mean
- 6.6. Combined Arithmetic Mean
- 6.7. Correction in Mean
- 6.8. Median - Individual Observation, Discrete Series, Continuous Series.
- 6.9. Determination of Median Graphically.
- 6.10. Partition Values – Quartiles, Deciles and Percentiles
- 6.11. Quartiles - Individual Observation, Discrete Series, Continuous Series.
- 6.12. Percentiles - Individual Observation, Discrete Series, Continuous Series.
- 6.13. Mode - Individual Observation, Discrete Series, Continuous Series.
- 6.14. Locating Mode Graphically
- 6.15. Comparison of mean, median and mode

Unit VII MEASURES OF DISPERSION (28 Periods)

- 7.1. Meaning and Significance of Measures of Dispersion.
- 7.2. Methods of studying Dispersion.
- 7.3. Absolute and Relative Measures of Dispersion.
- 7.4. Range - Individual Observation, Discrete Series, Continuous Series.

- 7.5. Coefficient of Range.
- 7.6. Quartile Deviation -Individual Observation, Discrete Series, Continuous Series.
- 7.7. Co efficient of Quartile Deviation
- 7.8. Mean Deviation - Individual Observation, Discrete Series, Continuous Series.
- 7.9. Co efficient of Mean Deviation
- 7.10. Standard Deviation - Individual Observation, Discrete Series, Continuous Series.
- 7.11. Co efficient of Standard Deviation/Variance
- 7.12. Qualities of a good measure of Dispersion.

Unit VIII CORRELATION

(18 Periods)

- 8.1. Meaning of Correlation
- 8.2. Types of Correlation
 - 8.2.1. Simple, Partial and Multiple
 - 8.2.2. Positive and Negative
 - 8.2.3. Perfect and Imperfect
 - 8.2.4. Linear and Non linear
- 8.3. Methods of studying correlation
 - 8.3.1. Scatter Diagram method
 - 8.3.2. Pearson's Co-efficient of Correlation
 - 8.3.3. Spearman's Rank Correlation

Unit IX INDEX NUMBERS

(22 Periods)

- 9.1. Meaning
- 9.2. Types of Index Numbers
 - 9.2.1. Price Index
 - 9.2.2. Quantity Index
 - 9.2.3. Cost of Living Index
 - 9.2.4. Whole Sale Price Index
- 9.3. Uses and Purpose
- 9.4. Methods of constructing Index Numbers
 - 9.4.1. Simple Index Number
 - 9.4.2. Weighted Index Number
 - Laspeyres' Method
 - Paasche's Method

Unit 1

Economic Environment for Management

- 1.1. Economic environment – Meaning and Significance
- 1.2. Basic concepts in Economic Environment
 - National Income: Gross Domestic Product, Net Domestic Product, Gross National Product, Net National Product
 - Methods of Measuring National Income
 - Value Added Method - Income Method - Expenditure Method
 - Problems in the calculation of National Income
 - Business Cycle - Phases of Business Cycle

Introduction

The success of a business not solely depends on its internal management, but also on many external forces. These external forces include consumers, other business firms, general economic conditions, Government laws and regulations. Business has to monitor the changes happening in these external forces and adapt to these changes for its survival. Economic environment is one of the main elements in business environment. The economic environment is composed of various sets of economic policies, economic system, national income, per capita income, infrastructure, capital formation, development strategy for economic growth and development, resources mobilisation, business cycle etc. This chapter deals with national income and its basic concepts, methods for its measurement and problems in its calculation.

Learning Outcomes

The learner;

- *Identifies the meaning of economic environment*
- *Explains basic concepts in economic environment*
- *States the importance of economic environment*
- *Explains various concepts of national income*
- *Analyzes the various methods of measuring national income*
- *Identifies the problem in the calculations of national income*
- *Identifies the meaning of business cycle*
- *Recognises the phases of business cycle*

Meaning of Economic Environment

Economic environment refers to the economic factors like economic conditions, economic policies and economic systems that influence the business in a country. The basic concepts in economic environment are:

1. Economic system

Economic system is a system, which functions in a country for the purpose of production and distribution of goods and services to satisfy the needs of the people. Economic system can be;

- a. **Capitalism**-Capitalism believes in private ownership of production and distribution facilities. The United States, Japan and United Kingdom are examples of capitalist countries.
- b. **Socialism**-Socialist economy is one where all means of production are collectively owned and it also ascribe a large role to the state. The erstwhile USSR is an example for socialist country.
- c. **Mixed economy**-Existence of both private and public sectors. France, Holland and India are examples of mixed economies.

2. Economic policies

Economic policies lay the framework within which every organisations has to function. Economic policies include;

- A. **Monetary policy**- Monetary policy is primarily concerned with the management of supply of money in a country. The main objective of monetary policy is to maintain price stability and ensure an adequate flow of credit to the productive sectors of the economy. In India, monetary policy is announced twice a year by Reserve bank of India. Monetary policy is also termed as credit control policy. Credit control can be of two types.

- (i) Quantitative credit control (ii) Qualitative credit control

- (i) **Quantitative credit control** - It regulates the volume of total credit and includes;

Bank rate policy- The bank rate, is the rate at which central bank would re-discount the eligible bills already discounted by commercial banks. The central bank can control the money supply in the country by revising the bank rate upwards and downwards.

Open market operations -The central bank may purchase or sell the securities in the open market and thereby control money supply in the economy. For example: suppose there is inflation, to bring down the money supply, the central bank would sell the securities. When there is deflation the central bank would buy the securities.

Variable reserve ratio- Variable reserve ratio refers to the increase or decrease in the statutory liquidity ratio and cash reserve ratio. By increasing the ratio the commercial banks would be left with lesser volume of funds to grant loans and prevent the inflation.

(ii) **Qualitative credit control** - Qualitative credit control means regulating the flow of credit through margin requirements, moral suasion, credit-rationing etc.

B. Fiscal policy - It is the means by which a Government adjust its spending levels and revenue collection to monitor and influence a nation's economy. In other words, fiscal policy is concerned with the determination of State income and expenditure policy. This is the policy, through which Government can encourage and restrict consumption, investment and saving habits in a country. One of the important goals of fiscal policy formulated by the Government of India is to attain rapid economic development of the country. The following are four important techniques of fiscal policy of india;

1. Taxation policy
2. Public expenditure policy
3. Public debt policy
4. Deficit financing policy

C. Foreign trade policy- Foreign trade policy determines the scope for trade between countries. A liberal policy would extend the scope for exports and imports while restrictive trade policy would narrow the scope for trade.

D. Licensing policy- Till 1991, India adopted licensing policy to regulate the growth of industries in India. After 1991 India adopted the policy of liberalisation, liberating the economy from strict rules.

E. Technology policy- The policy of using modern techniques in business.

F. Price policy- Price policy refers to the controls that Government has on the price in a country. Through price policy the Government protects the interest of the people.

Importance of Economic Environment

There is a close and continuous interaction between the business and its economic environment. Economic factors such as per capita income, national income, exploitation of natural resources, employment generation, propensity to consume, industrial development and so on, influence the business environment. Likewise, the economic performance of a country also determines the business environment. The interaction helps in strengthening the business firm and using its resources more efficiently. Economic environment helps the business in the following ways:

- Identifying opportunities and threats.
- Giving direction of growth.
- Continuous learning.
- Image building.
- Meeting competition.
- Identifying strength and weakness.

Assessment Activity

Suppose, as a result of budget announcement there will be a hike of ₹10,000 in the price of two wheelers from April 2016. Analyse its impact on two wheeler market on the basis of a) Sales b) profitability.

National Income

National income is the money value of all the final goods and services produced by a country during a period of one year.

For example, national income consists of millions of metres of cloth, tonnes of sugar, and millions of litres of milk. How can we measure the total income in this case? Since these goods are measured in different physical units, it is not possible to add them together. So the value of all goods and services produced is measured in terms of money, which is the common measure of value.

Basic concepts of National Income

1. Gross Domestic Product (GDP)

Gross domestic product is the money value of all final goods and services produced in the domestic territory of a country during a year.

- (a) Final goods – Final goods are those goods, which are being purchased for final use and not for resale or further processing.
- (b) Domestic territory-
 - Territory lying within the political frontiers, including territorial waters of the country
 - Ships and aircrafts operated by the residence of the country
 - Fishing vessels, oil and natural gas rigs and floating platforms operated by the residence of the country in the international waters.
 - Embassies, consulates and military establishments of the country located abroad.

2. GDP at constant prices and current prices

The domestic product estimated on the basis of the prevailing prices is called gross domestic products at current prices.

The domestic product measured on the basis of fixed prices, in some base year, is known as gross domestic product at constant prices.

3. GDP at factor cost and GDP at market price

GDP at market price is the money value of all goods and services produced in the domestic territory of a country during one year estimated at the prices prevailing in the market.

GDP at factor cost is the estimation of gross domestic product in terms of the earning of factors of production.

Conceptually, the value of GDP at market price and factor cost must be identical. This is because the final value of goods and services at market price must be equal to the cost involved in their production (factor cost).

4. Net Domestic Product (NDP)

Gross domestic product does not represent the true national income because it includes the full value of all goods, even capital goods. When depreciation allowance is subtracted from GDP we get Net Domestic Product.

Capital goods - Capital goods are those final goods which are durable and used in production process but do not get transformed in the production process. They form a part of capital and they gradually undergo wear and tear. For example machines, equipment, buildings etc.

$$\text{NDP} = \text{GDP} - \text{Depreciation}$$

5. Gross National Product (GNP)

Gross National Product is the total value of all goods and services produced by the nationals of a country within the country or outside the country. The value of goods and services produced by non-nationals in India will not be included in the Gross National Product of India.

$$\text{GNP} = \text{GDP} + \text{Income from abroad}$$

6. Net National Product (NNP)

Net National Product is the total value of final goods and services produced in an economy during a year after allowing for depreciation. Thus;

$$\text{NNP} = \text{GNP} - \text{Depreciation} \quad \text{OR}$$

$$\text{NNP} = \text{GDP} + \text{Income from abroad} - \text{Depreciation}$$

NNP is the 'National Income' of an economy. When NNP is divided by the Population of a country, we will get 'Per capita Income'

7. NNP at factor cost

NNP at factor cost is the volume of commodities and services turned out during an accounting year, counted without duplication. It can also be defined as the net value added at factor cost (by the resident) in an economy during an accounting year.

Assessment Activity

Form equations for different concepts of national income.

GNP at market price - depreciation = NNP at market price.

GNP at market price – net income from abroad = GDP at market price.

GDP at market price – net indirect taxes = GNP at factor cost.

NNP at market price – net income from abroad = NDP at market price.

NNP at market price – net indirect taxes = NNP at factor cost.

GDP at market price – net indirect taxes = GDP at factor cost.

GNP at factor cost – depreciation = NNP at factor cost

NDP at market price – net indirect taxes = NDP at factor cost.

GDP at factor cost – depreciation = NDP at factor cost.

Methods of measuring national income

There are three methods of measuring national income:

- (1) Value added method or product method
- (2) Income method
- (3) Expenditure method

1. Value added method or product method

According to value added method or product method or net output method, national income is measured by adding up the money value of all final goods and services produced in a country during one year. There are three steps in computing national income, under product method. They are:

a. Classify the economy into;

- i. Primary sector i.e. producing commodities by exploiting natural resources like land and water e.g. agriculture, forestry, fishing, mining etc.
- ii. Secondary sector i.e. manufacturing sector—transfers one type of commodity into another eg. manufacturing, construction, electricity, gas, water supply etc.
- iii. Tertiary sector i.e. service sector e.g. trade and commerce, transport and communication, banking, insurance Government and professional services.

b. Estimation of net value added

The second step is to find out the net value added at factor cost within the domestic territory of a country.

c. Estimation of National Income

The third step in estimating national income is estimating the net factor income earned from abroad. Net factor income from abroad consists of net compensation of employees, net income from property and entrepreneurship and net retained earnings of resident companies abroad. When we add the net factor income from abroad to the net domestic product we get the national income.

2. The income method

The income method measures national income from the side of the payments made to the primary factors of production for their productive services in an accounting year.

There are four steps involved in estimating national income by the income method. They are: (a) Identifying the production units employing factor services (b) Classifying factor payments (c) Estimating factor payments and (d) Estimating net factor income from abroad.

(a) Identifying the production units into primary sector, secondary sector and tertiary sector.

(b) Classifying factor payments

The factor payments are generally classified into;

compensation of employees - salaries and wages, employers contribution to social security and welfare funds, ration, uniform, housing, medical and education benefits
capital income- rent, interest, profits, royalties, dividends undistributed profits of companies etc.

mixed income - earning from agriculture, trade, transport, income from professions.

(c) Estimating factor payments

The third step is to estimate factor payments i.e. the number of units of each factor employed is multiplied with the income paid to each unit.

(d) Estimating net factor income from abroad

This is the last step in estimating national income. Compensation of employee's, capital income and mixed income earned by all the production units in the domestic territory of a country during an accounting year gives the domestic factor income. By adding the net factor income from abroad with the domestic factor income we get the national income.

3. Expenditure method

The expenditure method estimates national income by measuring final expenditure on gross domestic product. Final expenditure in an economy is the sum total of the expenditure incurred on final goods and services produced. It is the sum total of consumption expenditure and investment expenditure. The final expenditure on gross domestic products consists of:

- a. Private final consumption expenditure
- b. Government final consumption expenditure
- c. Gross fixed capital formation
- d. Changing stocks
- e. Net acquisition of valuables
- f. Net export of goods and services

Problems in the estimation of national income

Generally two types of difficulties are met within the estimation of national income. They are: - (a) conceptual difficulties (b) statistical difficulties

- (a). Conceptual difficulties – conceptual difficulties relate to definition of various concepts and terminology used in this process like definition of nation, method employed in the national income estimation, stage of economic activity at which national income is to be calculated and the type of commodities and services which are to be taken into account in national income.
- (b). Statistical difficulties – Lack of adequate data, lack of differentiation in economic function, double counting etc., are some of the statistical difficulties. In a developing country like India, a large portion of agriculture output does not come to the market at all and is retained either for barter purpose or for self-consumption. In unorganized sectors like small scale industries and trade, hotels and restaurants etc, data on production, capital formation etc are not satisfactory. In India, conditions not only differ between different states but also within each state. Information based on samples taken from a few districts may or may not be valid for the whole states. Occupational distribution of working population of India is not very clearly defined.

Assessment Activity

Calculate the value of goods produced by garment manufacturers assuming that cotton passes through four stages of production.

Value added at different stages

<i>Stages of Production</i>	<i>Value of output (Rs)</i>	<i>Value added (Rs)</i>
1 Cotton cultivation	100	100
2. Cloth Manufacturing	150	50
3. Garment Manufacturing	210	60
4. Retailer	250	40
Total	710	250

Explanation : If we add the value of different stages of production, total comes to ₹710. The customers pay only ₹250. This amount should be added while estimating the national income. This is because the value of the final product, i.e., the cotton garments is only ₹ 250.

Business Cycles

Economic activities never move on a straight line, it faces fluctuations. The wave like fluctuation in the level of economic activity is called business cycles. It may be defined as an alternate expansion and contraction in overall business activity, characterised by the periods-boom, recession, depression and recovery. Business cycle also known as trade cycle, affects the total income, investment, employment and output.

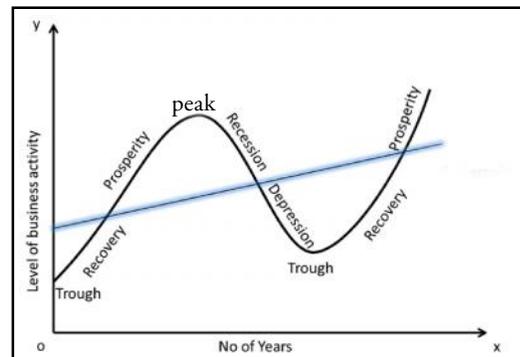
Phases of a Business Cycle

1.Boom (Prosperity or expansion): The boom phase means a state in which the real income consumed, the real income produced and the level of employment are higher or rising. All these bring up the economy to the **peak**.

2.Recession (contraction): Once the economy reached the **peak**, the course will change. A downward tendency in demand occurs. But the producers who are not aware of this go on producing. The supply now exceeds demand. When the producers come to know the situation they are compelled to give up the future investments. Business failures increase and unemployment expands. There is general distress.

3.Depression: During the phase of depression economic activity is at its low ebb. Wages, costs and prices are very low. There is massive unemployment and a fall in the aggregate income of the people. The lowest point at this phase is called '**trough**'

4.Recovery: Depression phase does not continue indefinitely. The idle workers now come forward to work at low wages, consumers start consuming, and banks come forward to give loans. Thus economic activity starts picking up.



Business cycles and Managers

Business cycles are reality. Every firm is a part of economy and hence cannot remain isolated. A thorough knowledge about business cycle, its impact on the economy are inevitable for business managers for forward planning and decision making. Periods of depression bring in pessimism and slacken business activity. Periods of boom create optimism and brighten business prospects. Signs of recession warn about probable losses and recovery signals potential opportunities. Thus the impact of every phase has to be analysed properly.

TE Questions

- The economic environment of business includes
 - Economic system
 - Economic policies
 - Economic conditions
 - All of these
- Net national product at factor cost is –
 - Equal to national income
 - more than national income
 - less than national income
 - always more than the gross national product
- Which of the following is incorrect?
 - $\text{GDP at market price} = \text{GDP at factor cost} + \text{net indirect taxes}$
 - $\text{NNP at factor cost} = \text{NNP at market prices} - \text{net indirect taxes}$
 - $\text{GNP at market prices} = \text{GDP at market prices} + \text{net factor income from abroad}$
 - None of the above.
- Expansion in general business activities : Inflation
Contraction in general business activities : _____
- Name the various methods of quantitative credit control policies of central bank.
- Differentiate GNP at market prices and NNP at market prices.
- Mention the three sectors in which an economy can be classified.
- Examine the various concepts related to national income.
- What are the various methods of estimating national income?
- What are the various difficulties involved in estimating national income in India?

Extended Activities

- Prepare a note on the new initiatives and policies adopted in India for the development of start-ups, small, medium and micro business units.
- Collect national income and per capita income data from new Economic Survey report available in the web site www.finmin.nic.in
- Collect monthly sales data of a particular year from 5 shops doing similar business in your town and analyze it on monthly-wise. Link your findings with the different phases of business cycle.

Unit 2

Working Capital Management

- 2.1. Meaning and Concepts of Working Capital
- 2.2. Components of Working Capital
- 2.3. Types of Working Capital
- 2.4. Meaning and Significance of Working Capital Management
- 2.5. Approaches to Working Capital Finance

Introduction

Every organisation requires broadly two kinds of capital. One for investing in fixed assets and another for financing routine activities. Investment in fixed assets is called fixed capital and investment in current assets is called working capital. This chapter deals with how working capital is managed by maintaining an optimum level of current assets and current liabilities.

Learning Outcomes

The learner;

- *Identifies the meaning of working capital*
- *States the importance of working capital*
- *Explains the concepts of working capital*
- *Compares gross working capital with net working capital*
- *Explains different components of working capital*
- *Identifies different kinds of working capital*
- *Analysis the factors affecting working capital*
- *States the meaning and importance of working capital management*
- *Explains different approaches to working capital finance.*

Meaning and Importance of Working Capital

If you propose to start a small business after completing the vocational higher secondary course, say a coffee shop. What all things do you need?

You require building, furniture, utensils, sugar, coffee powder, cash to pay wages and other day-to-day expenses. For all these we need money or capital.

Every business needs funds for two purposes - for its establishment and to carry out its day-to-day operations. The investment made in the fixed assets like building, furniture, utensils etc. is called fixed capital. Funds needed for the purchase of sugar, tea powder etc. and payment of wages and other day to day expenses are known as working capital. Thus, working capital is the sum of money needed to finance current assets.

No business can run successfully without an adequate amount of working capital. The importance of maintaining adequate amount of working capital is as follows:

1. Solvency of the business-Adequate working capital ensures solvency of the business by providing uninterrupted flow of production.
2. Goodwill-Sufficient working capital enables a business to make prompt payments and it will enhance the goodwill of the firm. It also helps to arrange loans on easy and favourable terms.
3. Cash discount- With adequate amount of working capital the business can make cash purchases and thereby avail cash discount.
4. Regular payments of salaries, wages and other day to day commitments-Regular and prompt payment of employees' claims is possible only if sufficient working capital is available. This will raise their morale and eventually leads to increase in efficiency.
5. Exploitation of favourable market conditions- Adequate amount of working capital helps the firm to exploit favourable changes in the market such as reduction in the price of raw materials, unexpected demand for product, etc.
6. Ability to face crisis - Sufficient working capital provides a buffer to face uncertainties.
7. High morale- Adequacy of working capital creates an environment of security, confidence, high morale and enhance overall efficiency in business.

Concepts of Working Capital

The different concepts of Working Capital are :

- (i) **Gross Working Capital-** The sum total of all current assets of a business concern is called as gross working capital. Current assets are those assets which can be converted into cash within a short period of time ie, one year.
- (ii) **Net working capital-** Net working capital is the difference between current assets and current liabilities. Current liabilities are those liabilities which are intended to be paid within one accounting year.

$$\text{Net working capital} = \text{current assets} - \text{current liabilities}$$

Net working capital may be:

- (a) Positive working capital:- excess of current assets over current liabilities.
- (b) Negative working capital;- excess of current liabilities over current assets.
- iii). **Permanent or fixed working capital:** There is always a minimum level of current assets which is continuously required by the enterprise to carry out its normal business operations. For example, a minimum level of raw materials, work in progress, finished goods and cash balance. This minimum level of current assets is called fixed working capital
- iv). **Temporary or variable working capital-** This is the amount of working capital which is required to meet the seasonal demands and some special exigencies.

Components of working capital

Working capital is composed of various current assets and current liabilities, which are as follows;

(A) Current Assets : Current assets include:

- a) Inventory
 - i. Raw materials
 - ii. Work-in-progress
 - iii. Consumable stores
 - iv. Finished goods
- b) Sundry debtors
- c) Bills receivables
- d) Pre-payments
- e) Short term investments
- f) Accrued income
- g) Cash and bank balances

(B) Current liabilities: Current liabilities include:

- a) Sundry creditors
- b) Bills payables
- c) Accrued expenses
- d) Bank overdrafts
- e) Proposed dividends
- f) Short term loans
- g) Tax payments due

Assessment Activity

Compute gross working capital and net working capital from the given balancesheet

Balancesheet of ABC ltd. as on 31.3.2015

Liabilities	Rs.	Assets	Rs.
Equity shares	400000	Goodwill	40000
8% debentures	200000	Land and building	300000
Reserves & Surplus	100000	Plant and machinery	200000
Sundry creditors	300000	Finished goods	120000
Bill payable	60000	Work-in-progress	80000
Outstanding expenses	40000	Prepaid expenses	40000
Bank overdraft	100000	Marketable securities	120000
Provision for tax	40000	Sundry debtors	180000
Proposed dividend	60000	Bill receivables	40000
		Cash & bank	180000
Total	1300000	Total	1300000

As per the balancesheet

1) **Gross working capital**= total of current assets

ie., $120000 + 80000 + 40000 + 120000 + 180000 + 40000 + 180000 = ₹7,60,000$

2) **Net working capital** = current assets – current liabilities

Current assets = ₹7,60,000

Current liabilities = $300000 + 60000 + 40000 + 100000 + 40000 + 60000 = ₹600000$.

Net working capital = $760000 - 600000 = ₹160000$.

Factors determining the working capital requirements

The working capital requirements of a concern depend upon a number of factors such as:

1. **Nature of business**-The working capital requirements of a firm basically depends upon the nature of its business. Public utility undertakings like electricity, water supply and railways need very limited working capital because they offer cash sales only and supply services, not products, and as such no funds are tied up in inventories and receivables. On the other hand, trading and financial firms require investment of large amounts in current assets like inventories, receivables and cash.

2. **Size of business-** Greater the size of a business unit, generally larger will be the requirements of working capital. However, in some cases even smaller concern may need more working capital due to high overhead charges and other economic disadvantages of small size.
3. **Production policy-**In certain industries the demand is subjected to wide fluctuations due to seasonal variations. If the policy is to keep production steady by accumulating inventories it will require higher working capital.
4. **Length of production cycle-**In manufacturing business, the requirements of working capital increase in direct proportion to length of manufacturing process.
5. **Working capital cycle-** In a manufacturing concern the working capital cycle starts with the purchase of raw materials and ends with the realisation of cash from the sale of finished products. Larger the period of the cycle, larger is the requirement of working capital.
6. **Rate of stock turnover** – A firm having a high rate of stock turnover will need lower amount of working capital as compared to a firm having a low rate of turnover.
7. **Credit policy-** A concern that purchases its requirements on credit and sells its products on cash requires lesser amount of working capital. On the other hand, a concern buying its requirements for cash and allowing credit to its customers shall need larger amount of working capital.
8. **Business cycles-** In a period of boom, there is a need for large amount of working capital. In times of depression there will be large amount of idle working capital.
9. **Rate of growth of business** - The working capital requirements of a concern increases with increase in the growth of business activities. For a firm with normal rate of growth and expansion of business, the retained profit may be used for additional working capital. But fast growing concerns require large amount of working capital.
10. **Dividend policy-** A firm that maintains a steady high rate of cash dividend needs more working capital than the firms that retains larger part of its profits.
11. **Price level changes-** Generally, the rising prices will require the firm to maintain larger amount of working capital to maintain the same level of current assets.
12. **Other factors-** Operating efficiency, management ability, irregularities of supply, import policy, importance of labour, banking facilities etc., also influence the requirements of working capital.

Working Capital Management: Meaning and Significance

Working capital management means planning, organising directing and controlling of

working capital. It is concerned with the management of current assets and current liabilities of a firm in such a way that a satisfactory level of working capital is maintained. The aim of working capital management is to deploy such amount of current assets and current liabilities so as to maximise short term liquidity. The two steps involved in the working capital management are;

1. Forecasting the amount of working capital
2. Determining the sources of working capital

Both excess as well as deficit working capital position are bad for any business. Working capital management policies of a firm have great effect on its profitability, liquidity and structural health of the organisation.

Disadvantages of excessive working capital

1. Idle funds earn no profits for the business.
2. Accumulation of inventories causing more chances of theft, waste and losses.
3. Defective credit policy cause higher incidence of bad debts.
4. Due to low rate of return on investments, the value of shares may fall.
5. The redundant working capital gives rise to speculative transactions.

Dangers of inadequate working capital

1. A concern with inadequate working capital cannot pay its short term liabilities in time. This will lose its reputation and shall not be able to get good credit facilities.
2. The concern cannot avail the benefit of bulk purchase and discounts.
3. It becomes difficult for the firms to exploit favourable market condition.
4. The firm cannot pay the day-to-day expenses of its operations.
5. The firm is not possible to utilise the fixed assets due to non – availability of liquid cash.
6. The rate of return on investment also falls with the shortage of working capital.

Out of the two situations, i.e. excess or inadequacy of working capital, the inadequacy of working capital is more dangerous from the point of view of the firm.

Approaches to working capital finance

Broadly speaking, there are two sources for financing working capital requirements:

- a. **Long term sources**- share capital, debentures, public deposits, plough back of profits, loans from financial institutions etc.
- b. **Short term sources**- Short term fund from commercial banks, indigenous bankers, trade creditors, instalment credit, advances, accounts receivables etc.

The management has to decide the proportion of short term and long term sources of finance to be included in the total working capital requirements. There are three basic approaches for determining the mix to finance working capital. They are:

1. Conservative approach

According to this approach, the entire estimated investment in current assets should be financed from long term sources, and short term sources should be used only for emergency requirements. The main features of this approach are:

- a) Liquidity is severally greater
- b) Risk is minimized
- c) The cost of financing is relatively high

2. The aggressive approach

The aggressive approach suggests that the entire estimated requirements of current assets should be financed from short term sources and even a part of fixed assets investments be financed from short term sources. The main features of this approach are:

- a) More risk
- b) Less costly
- c) More profitable

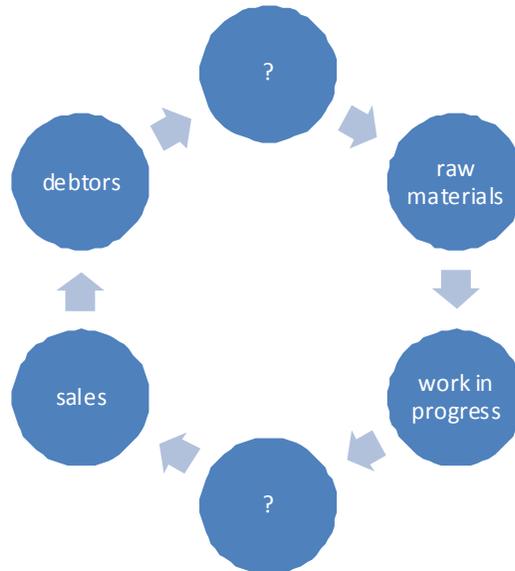
3. The hedging or matching approach

The term hedging usually refers to off setting transaction of a simultaneous but opposite nature which counters balance the effect of each other. The hedging approach suggests that the permanent working capital requirements should be financed with funds from long term sources while the temporary or seasonal working capital requirements should be financed with short term funds.

TE Questions

1. Gross working capital is equal to:
 - a) Total of current assets
 - b) Total of current liabilities
 - c) Current assets-current liabilities
 - d) None of the above
2. According to conservative approach of working capital management, current assets should be financed from
 - a) Long term sources
 - b) Short term sources
 - c) Both Long term sources and Short term sources
 - d) None of the above

3. Complete the diagram



4. Find odd one out and state reason.
Land and building, cash in hand, cash at bank, sundry debtors.
5. Give a short note on Hedging?
6. List out the factors determining working capital requirements?
7. What are the different components of working capital?

Extended Activities

1. Visit a small enterprise working in and around your location. Ask the entrepreneur how he arranged his working capital? Identify the major problems he faces in arranging working capital.
2. Prepare a list of formal agencies in Kerala that provide working capital finance to small entrepreneurs.

Unit 3

Long Run Investment Decision – Capital Budgeting

- 3.1. Meaning and Importance of Capital Budgeting
- 3.2. Methods of Capital Budgeting – Traditional
 - Pay Back Method
 - Average Rate of Return Method
- 3.3. Methods of Capital Budgeting – Discounted Cash Flow Methods
 - Net Present Value Method
 - Profitability Index Method
 - Internal Rate of Return Method

Introduction

The allocation of funds of a concern mainly depends on its investment decision. It is a choice of assets such as short term or current assets and long term or fixed assets where funds will be invested. The investment decision which relates to the short term or current assets is known as working capital management or current assets investment decision whereas the investment decision relating to the long term or fixed assets is known as capital budgeting or capital expenditure decision or long term investment decision.

Learning Outcomes

The learner;

- *Identifies the meaning of capital budgeting*
- *States the importance of capital budgeting*
- *Recognizes the process of capital budgeting*
- *Classifies different types of capital budgeting methods*
- *Explains the concept of Pay Back Period method*
- *Explains the concept of Average Rate of Return method*
- *Compares between Pay Back Period method and Accounting Rate of Return method*
- *Explains the concept of Net Present Value Method*
- *Explains the concept of IRR Method*
- *Explains the concept of Profitability Index Method*
- *Classifies different types of Discounted Cash flow techniques*
- *Differentiate between Traditional Methods and Discounted Cash flow techniques*
- *Solves problems by using different formulae*

Meaning of Capital Budgeting

A progressive business firm continually needs to expand its fixed assets and other resources to be competitive in the race. Investment in fixed assets is an important indicator of business growth. The success of an organisation in the long run depends upon the effectiveness with which the management makes capital expenditure decisions.

The term Capital Budgeting refers to the process of decision making with regard to the investment in fixed assets (ie, long term assets and capital projects). It involves long-term planning for proposed capital expenditure for maximizing return on investments. The capital expenditure may be;

- Cost of acquisition of fixed assets. e.g., land, building and machinery etc.
- Cost of mechanization, automation and replacement.
- Investment on research and development.
- Cost of development and expansion of existing and new projects.

Importance of Capital Budgeting

Capital budgeting is important because of the following reasons:

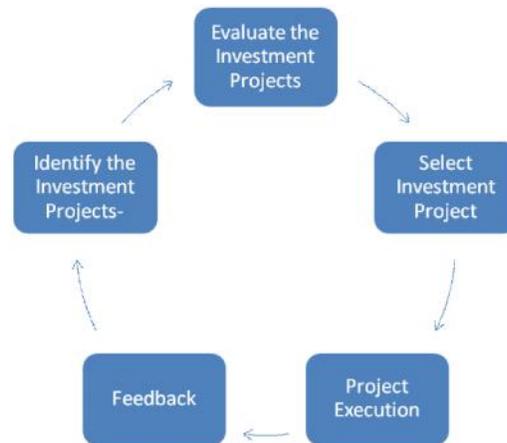
- **Cost:** Initial investment is huge. Hence, these decisions are planned after careful evaluation of various projects.
- **Time:** The effect of the decision is known only in the near future and not immediately.
- **Irreversibility:** These decisions once taken are not easily reversible without incurring huge loss.
- **Risk:** The longer the time period of returns, the greater is the risk. Hence decisions should be taken after a careful review of all available information.
- **Complexity:** Decisions are based on forecasting of future events and inflows. Quantification of future events involves application of statistical and probabilistic techniques.

Process of Capital Budgeting

The process of capital budgeting decision involves five steps;

1. **Identify the Investment Projects** -The first and crucial process of any investment decision is the recognition of opportunities. Several opportunities are available for investment but only promising opportunities that are compatible with firms objectives should be identified

2. **Evaluate the Investment Projects** - It is necessary to estimate inflows and outflows of each of the investment projects. Evaluations are done by using different capital budgeting techniques.
3. **Select Investment Project** - After evaluation, the top management by considering returns, risk as well as the cost of capital, chooses that project which maximises the shareholders' wealth.
4. **Project Execution**- Once the selection is made, the project will be implemented by acquiring necessary funds for financing the project.
5. **Feedback**- After the execution of the project, its progress must be monitored with the help of feedback reports. Actual performance should be compared with the expected one and deviations, if any, should be properly addressed.



Methods of Capital Budgeting

Capital budgeting techniques (Investment appraisal criteria) can be divided into following two groups:

Non-Discounted Cash Flow Methods (Traditional Methods)

- Payback Period (PBP)
- Accounting Rate Of Return (ARR)

Discounted Cash Flow Methods (Modern or Time adjusted Methods)

- Net Present Value (NPV)
- Profitability Index (PI)
- Internal Rate of Return (IRR)

Non-Discounted Cash Flow Methods (Traditional Methods)

(a) Payback Period (PBP) :

The payback period (PBP) is a traditional method of capital budgeting. It is the simplest and perhaps, the most widely used quantitative method for appraising capital expenditure decisions.

PBP is the number of years required to recover the original cash outlay invested in a project.

Computation of PBP

There are two methods of calculating the PBP.

(a) The first method can be applied when the annual cash inflow is uniform. In such a situation the initial cost of the investment is divided by the constant annual cash flow: For example, if an investment of ₹100000 in a machine is expected to generate cash inflow of ₹20,000 per annum for 10 years. Its PBP will be calculated using following formula:

$$\begin{aligned} \text{PBP} &= \text{Initial Investment} / \text{Constant Annual Cash Inflow} \\ &= 100000/20000 = 5 \text{ years} \end{aligned}$$

(b) The second method is used when a project's annual cash inflows are not equal. In such a situation PBP is calculated by the process of cumulating annual cash inflows till the time when cumulative cash flow becomes equal to the original investment outlays.

For example, A firm requires an initial cash outflow of ₹20,000 and the annual cash inflows for 5 years are ₹6000, ₹8000, ₹5000, ₹4000 and ₹4000 respectively. Calculate PBP. Here, When we cumulate the cash flows for the first three years, ₹19,000 is recovered. In the fourth year ₹4000 cash flow is generated by the project but we need to recover only ₹1000. So the time required for recovering ₹1000 will be $(\text{₹}1000/\text{₹}4000) \times 12 \text{ months} = 3 \text{ months}$. Thus, the PBP is 3 years and 3 months (3.25 years).

Decision Rule:

The PBP can be used as a decision criterion to select investment proposal.

- If the PBP is less than the maximum acceptable payback period, accept the project.
- If the PBP is greater than the maximum acceptable payback period, reject the project.

This technique can be used to compare actual payback period with a standard payback period set up by the management in terms of the maximum period during which the initial investment must be recovered.

Uses:

The PBP can be gainfully employed under the following circumstances.

1. The PB method may be useful for the firms suffering from a liquidity crisis.
2. It is very useful for those firms which emphasizes on short run earning performance rather than its long term growth.
3. The reciprocal of PBP is a good approximation of IRR (Internal Rate of Return) which otherwise requires trial & error approach.

Advantages

1. This method is **simple** to calculate and easy to operate.
2. It is suitable in the case of industries where the risk of **technological obsolescence is very high**.
3. It clarifies the concept of **profit or surplus**.
4. When **funds are limited** projects having shorter payback should be selected.
5. This method **promotes liquidity** by stressing on projects with earlier cash inflows.

Limitations

1. It stress on **capital recovery** rather than profitability.
2. It does not consider **post payback cash flows**.
3. This method ignores **time value of money**.

Assessment Activity

From the following two projects find out the most feasible project according to Payback Period Method.

	Project A	Project B
Initial Investment	10000	10000
Cash inflow – Year 1	4000	3000
Cash inflow – Year 2	4000	3000
Cash inflow – Year 3	2000	3000
Cash inflow – Year 4	-----	3000
Cash inflow – Year 5	-----	3000

(b) Accounting/Average Rate of Return (ARR):

The ARR is the ratio of the average profit after tax divided by the average investment.

This method is also known as the Return On Investment (ROI), Return On Capital Employed (ROCE) and is using **accounting profit** rather than cash flow to evaluate investment proposals.

Accounting profit is the difference between total monetary revenue and total monetary costs, and is computed by using Generally Accepted Accounting Principles (**GAAP**).

Accounting profit = total monetary revenue - total costs.

Computation of ARR

The most common method of computing ARR is

$$\text{ARR} = \frac{\text{Average Annual Profit after Tax}}{\text{Average Annual Investment}} \times 100$$

For example, a project requires an investment of ₹10,00,000. The plant & machinery required under the project will have a scrap value of ₹80,000 at the end of its useful life of 5 years. The profits after tax and depreciation are estimated to be as follows:

Year	1	2	3	4	5
Profit after tax (Rs)	5000	75000	125000	130000	80000

We shall calculate ARR using above formula.

$$\text{ARR} = \frac{(50000+75000+125000+130000+80000)/5}{(1000000+80000)/2} \times 100 = 17.04\%$$

Decision Rule:

The ARR can be used as a decision criterion to select investment proposal.

- If the ARR is higher than the minimum rate established by the management, accept the project.
- If the ARR is less than the minimum rate established by the management, reject the project.

The ranking method can also be used to select or reject the proposal using ARR. Highest rank would be given to a project with highest ARR and lowest rank would be given to the project with lowest ARR.

This is the only method considering accounting profit for decision making and irrelevant for today's business decisions.

Discounted Cash Flow Methods

Discounted Cash Flow Methods take into consideration **time value of money**. In an economy, money grows at a particular rate. Therefore, one rupee received today is more worthy than one rupee received tomorrow. This concept is called time value of money. The present value of future cash inflows is computed by **discounting** at an appropriate discount rate and projects are evaluated on that basis. These methods are also known as **modern or time adjusted techniques**.

(a) Net Present Value (NPV)

Net Present Value (NPV) is the difference between the present value of cash inflows and the present value of cash outflows. NPV is used in capital budgeting to analyse the profitability of a proposed investment or project.

NPV recognises that cash flow streams at different time period differs in value and can be computed only when they are expressed in terms of common denominator i.e. present value.

The procedure for determining the present values consists of two stages. The first stage involves determination of an appropriate discount rate. With the discount rate so selected, the cash flow streams are converted into present values in the second stage.

Computation of NPV

The important steps for calculating NPV are given below.

1. Annual cash flows of the investment project should be forecasted based on realistic assumptions. These cash flows are the incremental cash inflow after taxes but before depreciation.
2. Appropriate discount rate should be identified to discount the forecasted cash flows.
3. Present value (PV) of cash flows should be calculated by multiplying with appropriate discount rate.
4. NPV should be found out by subtracting present value of cash outflows from present value of cash inflows.

Decision Rule:

The present value method can be used as an accept-reject criterion. The present value of the future cash streams or inflows would be compared with present value of outlays. The present value of outlays are the same as the initial investment.

- If the NPV is greater than 0, accept the project.
- If the NPV is less than 0, reject the project.

Advantages

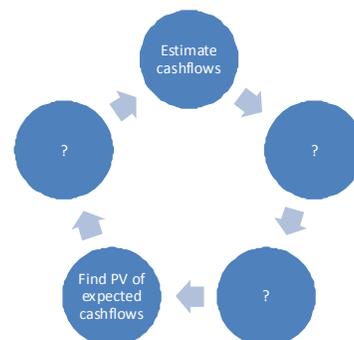
1. It considers the concept of **time value of money**.
2. Unlike payback period, all **cash flows** are considered.

Limitations

1. It involves **complex calculations in discounting** and present value calculations.
2. It **ignores the difference in initial cash outlays**, size of different proposals etc.

Assessment Activities

1. From the diagram given, complete the empty circles.
2. Calculate NPV for a Project X initially costing Rs.250000. It has 10% cost of capital.



It generates following cash flows:

Year	Cashflows	PV@10%
1	90000	.909
2	80000	.826
3	70000	.751
4	60000	.683
5	50000	.621

b) Profitability Index (PI)

Profitability Index (PI) or Benefit-cost ratio (B/C) is similar to the NPV approach. PI approach measures the present value of returns per rupee invested. It is observed as a shortcoming of NPV that, being an absolute measure, it is not a reliable method to evaluate projects requiring different initial investments. The PI method provides solution to this kind of problem. It is a relative measure and can be defined as the ratio which is obtained by dividing the present value of future cash inflows by the present value of cash outlays.

$$PI = \text{Total discounted Cash inflows} / \text{Initial cash outlay}$$

This method is also known as B/C ratio because numerator measures Benefits and denominator Cost.

Decision Rule:

Using the PI ratio,

- Accept the project when $PI > 1$
- Reject the project when $PI < 1$
- May or may not accept when $PI = 1$, the firm is indifferent to the project.

Advantages

1. This method considers time value of money.
2. It is a better project evaluation technique than NPV, and helps in ranking projects where NPV is positive.

Limitation

1. It fails as a guide in resolving capital rationing problems, when projects are indivisible.

c) Internal Rate of Return (IRR):

Internal rate of return (IRR) is the **discount rate at which the net present value of an investment becomes zero**. In other words, IRR is the **discount rate which equates the present value of the future cash flows of an investment with the initial investment**.

IRR refers to that discount rate (Kt) such that

$$\sum \{ \text{Period Cash Flow} / (1+R)^T \} - \text{Initial Investment} = 0$$

where R is the interest rate and T is the number of time periods. IRR is calculated using the NPV formula by solving for R if the NPV equals zero.

Decision Rule

Advantages

1. Time value of money is taken into account.
2. All cash inflows of the project, arising at different points of time are considered.
3. Decisions are immediately taken by comparing IRR with the Firm's cost of capital.
4. It helps in achieving the basic objective of achieving shareholders wealth.

If	Decision
IRR > K _o	Accept the project. Returns over and above the cut-off rate is obtained.
IRR = K _o	Project generates cash flows at a rate just equal to the cost of capital. Hence, it may either be accepted or rejected. This constitutes the indifference point.
IRR < K _o	Reject the project. The project does not provide returns even equivalent to the cut-off rate.

Limitations

1. IRR is only an approximation and cannot be computed exactly without the use of computers.
2. It is tedious to compute in case of multiple cash outflows.

Example:

The management of VGA Textile Company is considering to replace an old machine with a new one. The new machine will be capable of performing some tasks much faster than the old one. The installation of machine will cost ₹8,475 and will reduce the annual labour cost by ₹1,500. The useful life of the machine will be 10 years with no salvage value. The minimum required rate of return is 15%.

Required: Should VGA Textile Company purchase the machine? Use internal rate of return (IRR) method for your conclusion

Solution:

To conclude whether the proposal should be accepted or not, the internal rate of return promised by machine would be found out first and then compare to the company's minimum required rate of return.

The first step in finding out the internal rate of return is to compute a discount factor called internal rate of return factor. It is computed by dividing the investment required for the project by net annual cash inflow to be generated by the project. The formula is given below:

$$\text{IRR Factor} = \frac{\text{Investment required}}{\text{Net annual cash inflow}}$$

In our example, the required investment is ₹8,475 and the net annual cost saving is ₹1,500. The cost saving is equivalent to revenue and would, therefore, be treated as net cash inflow. Using this information, the internal rate of return factor can be computed as follows:

$$\text{Internal rate of return factor} = ₹8,475 / ₹1,500 = 5.650$$

After computing the internal rate of return factor, the next step is to locate the discount factor in “present value of an annuity of ₹1 in arrears table”. Since the useful life of the machine is 10 years, the factor would be found in 10-period line or row. After finding this factor, see the rate of return written at the top of the column in which factor 5.650 is written. That is 12%. It means the internal rate of return promised by the project is 12%. The final step is to compare it with the minimum required rate of return of the VGA Textile Company. That is 15%.

According to internal rate of return method, the proposal is not acceptable because the internal rate of return promised by the proposal (12%) is less than the minimum required rate of return (15%).

Notice that the internal rate of return promised by the proposal is a discount rate that equates the present value of cash inflows with the present value of cash outflows as proved by the following computation:

Present value of cash outflow		₹8,475 × 1.000 = ₹8,475
Present value of cash inflow	1-10 year-period @ 12%	₹1,500 × 5.650 = ₹8,475

Assessment Activity

A company proposes to install a machine involving a capital cost of ₹360000/-. The life of the machine is 5 years and its salvage value at the end of the life is nil. The machine will produce the net operating income after depreciation of ₹68000/- per annum. The company's Tax Rate is 45%. Calculate IRR of the proposal. The PV factors for 5 years is as under-

Discounting factor	14	15	16	17	18
Cumulative factor	3.43	3.35	3.27	3.20	3.13

TE Questions

- The value of a Rupee to be received in future is less than the value of a Rupee on hand today is the concept of;
 - Compounding
 - Discounting
 - Budgeting
 - Time Value of money
- Find the odd one out and state the reason.
 - NPV
 - IRR
 - ARR
 - Profitability Index
- Complete the series

$$\text{NPV} = \text{PV inflows} - \text{PV outflows}$$

$$\dots\dots\dots = \text{PV inflows} - \text{PV outflows} = 0$$
- What is meant by the concept of Accounting Profit?
- Briefly explain the importance of capital budgeting.
- What are the various steps involved in the capital budgeting process? Show the steps with the help of a diagram.
- Explain the advantages and disadvantages of Payback period method.
- You are required to find out the NPV of the following projects, assuming that the cost of capital is 10% and the initial investment is ₹1600 each.

Year	Project A net cashflows (Rs)	Project B net cashflows (Rs)
1	800	200
2	800	400
3	400	400
4	200	400
5	600
6	800

Extended activity

Visit a small scale industrial unit and examine their project reports and prepare an account of capital budgeting techniques used for the evaluation of projects.

Unit 4

Production and Operations Management

- 4.1. Meaning and Importance of Production and Operations Management
- 4.2. Difference between Production and Operation
- 4.3. Major Decisions of Production Management
- 4.4. Plant Location and factors affecting plant location
- 4.5. Plant Layout and different types of Plant Layouts
- 4.6. Aggregate Planning – Meaning, Importance and Strategies
- 4.7. Master Production Scheduling - Meaning, Significance and Development of Master Production Schedule (MPS)

About the Unit

The reason for the existence of any organization is to fulfill the wants of the customer. These wants may be fulfilled through tangible products or intangible services. The management of manufacturing of products is referred to as Production Management and the functions dealing with the operation of services are covered under Operations Management. This unit throws light on the meaning and importance of Production and Operation Management and some important management concepts coming under the function of production and operation.

Learning Outcomes

The learner;

- *States the meaning and importance of production and operation management.*
- *Distinguishes between production and operation*
- *Identifies various types of decisions in production and operations management*
- *Distinguishes between various types of decisions in production and operations management*
- *Identifies the importance of plant location*
- *Lists out various factors affecting plant location*
- *Identifies concept of plant layout*
- *States the importance of plant layout*
- *Suggests suitable types of plant layout*
- *Explains the concept aggregate planning, its meaning and importance*
- *Identifies the strategies used in aggregate planning*

- *Explains the Concept of master production scheduling*
- *Develops a master production schedule (MPS)*

Meaning and Importance of Production/Operation Management

• Meaning of Production Management

Having once set up the enterprise, the future survival of enterprise whether micro, small, medium or large depends upon its profit earning capacity. The profit earning capacity of any enterprise depends upon the right decision taken by the entrepreneur regarding investment, location of the plant, product design, quality control, technology etc. All these decisions come under the purview of production management.

The term production is used to indicate a process through which raw materials are converted into finished product. *Production Management* refers to the application of *management* principles to the *production* function in a factory. In other words, *production management* involves application of planning, organising, directing and controlling the *production* process.

Assessment Activity

Discuss the following and define the term production;

- the process is carried out in a factory
- management functions
- application of management functions in production

• Importance of Production Management

The main aim of Production function is to produce the goods and services economically to the full satisfaction of the customer for which they are meant. In order to achieve this aim, it is essential to plan, organise, direct and control the production system.

Assessment Activity

Which one of the following is a correct statement ;

1. Production and operation management helps to produce goods and services economically
2. Production and operation management helps to produce goods which satisfy the customers
3. Production and operation management plans, organises, directs and controls the production system
4. All the above

Difference between Production and Operation

The term production is strictly used in the sense of manufacturing tangible products. The term operation involves services. The differences between production and operations are as follows:

<i>Production</i>	<i>Operation</i>
Manufacturing of tangible product	Rendering of Services
Used in narrow sense	Used in broad sense
Applied to manufacturing organisations	Applied to non-manufacturing organisations
Have closing stock	No closing stock
Demand is regular	Demand fluctuate

Assessment Activity

Observe the following points and arrange them under the heads production and operation in a logical order.

no closing stock
narrow sense
non-manufacturing organisations
closing stock
regular demand
tangible product
services
broad sense
fluctuating demand
manufacturing organisations

Fill the missing points.

Production	Operation
Manufacturing of	Rendering of
Used in sense	Used in sense
Applied to Organisations	Applied to organisations
Have closing stock
..... is regular	Demand

Major Decisions of Production Management

Decisions can be classified into a. Strategic b. Tactical and c. Operational.

1. Strategic Production Planning

Strategic planning involves deciding and developing strategic plans to achieve strategic objectives (or goals). Top management typically develops strategic plans. These decisions or plans are normally long term decisions, which are having implications for the next five years and above. Lot of risk and uncertainty is involved in long term or strategic level planning. Strategic planning needs a through scanning and analysis of external environment to seek information.

Strategic Planning include;

- Technology decisions: Choice of appropriate technology, equipments, process choice and degree of automation.
- Capacity decisions: Amount, timing and type.
- Facilities decisions: Size, location and specializations
- Vertical integration: Direction, extent and balance

2. Tactical Production Plan

Tactical planning is done at middle management level medium term planning (ranging between 2 to 3 years) concerned with deciding specifically how the resources of the organization will be utilized to achieve the organizational strategic goals. Tactical planning involves less uncertainty and hence lower risk compared to strategic planning. Mainly the planning requires internally generated data.

Tactical planning includes:

- Establishing the parameters for measuring operational efficiency and productivity. Making plans to improve utilization of existing resources.
- Prepare an equipment and manpower planning.
- Planning for modernization of the facilities and automation.
- Developing specific technology and tools to enhance production efficiency or productivity.
- Prepares work plans for process redesign, methods improvement and job design.
- Make or buy decision.
- Projections regarding skill requirements for future work assignment and prepare the skill development plans.
- Planning for medium term maintenance (preventive and condition monitoring) to enhance the availability of production facilities.

3. Operational Level Production Planning:

The operational planning decisions are taken at the lower level of management and these are routine decisions. These plans are prepared to establish actions necessary for achieving operational goals. These cover shorter time frame i.e. within a year. No or very less uncertainty in these plans and information needed is internal. They are stated in definite quantitative terms and can be spelt out in terms of time and targets.

Operational level planning includes;

- What is the job
- On which machine/machines it is to be processed (sequence of operations)
- Who should do this job – operator details
- Starting and finishing times of each job in each of the workstation or machines or facilities
- Quality specifications and inspection, and test details

Thus, the operational production plan gives all the details regarding the processing of the product from raw material stage to finished goods ready for dispatch after quality check and performance testing.

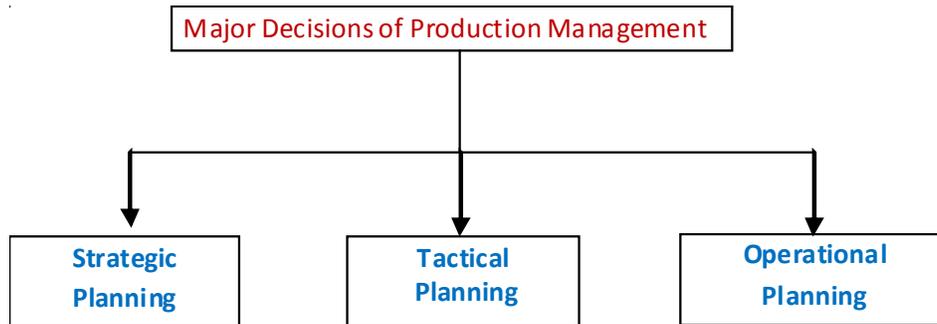
Assessment Activity

a) Classify the following Decisions into Strategic, Tactical and Operational.

- The type of technology to be adopted
- Parameters for measuring operational efficiency
- What type of job
- Prepares work plans for process redesign and job design
- Selects the machine for production
- Who should be the operator
- When should the job start
- What should be the quality
- Improve utilisation of existing resources
- Plant capacity
- Plan for modernisation
- Specific technology and tools to enhance production efficiency or productivity
- Make or buy decision
- Location of the plant
- Prepare equipment and manpower planning
- Projection regarding skill requirements

- Plan for medium term maintenance (preventive and condition monitoring) to enhance the availability of production facilities

b) Observe the following chart and prepare a short note on it;



Plant Location and factors affecting plant location

The location of a plant should be fixed in such a manner that the firm can sell their products most profitably and manufacture them with the least expense.

Factors affecting plant location

Buying

- Nearness to raw materials
- Accessibility of raw materials

Manufacturing

- Proximity to large adaptive labour
- Nearness to sources of power
- Ready accessibility to repair shops
- Nearness to good banking and credit facilities
- Adequate transport and communication facilities
- Ability to build and expand plant cheaply
- Government regulation and subsidy
- Adequate fire fighting facilities
- State of organisations and development of learning
- Suitable soil, climate and topography

Association with other Industries

- Complementary industries
- Competing industries
- Momentum of an early start

Assessment Activity

CASE STUDY

Study the following case and answer the questions below:

Mr. Avinash wants to start a Prawn Processing industry in Kerala. He is a native of Idukki and wanted to start such factory in Thodupuzha, since it is in his own district and very accessible to Kochi. But when consulted with an owner of such a factory from Kollam district, his opinion was to start at Neendakara, Kollam. He tells Avinash that if he starts in Kollam he can easily avail the raw materials at competitive prices. There are also plenty of skilled labourers around and many such industries of the same nature nearby. So it will be easier to get license. Plant can be established without much difficulty and already there are supporting industries nearby.

What are the advantages if a Prawn Processing industry is started in Kollam district

What difficulties Avinash may face if he starts such a business in Thodupuzha?

Plant Layout

Plant layout refers to the arrangement of physical facilities such as machines, equipment, tools, furniture etc. in such a manner so as to have quick flow of material at the lowest cost and with the least amount of handling in processing the product from the receipt of raw material to the delivery of the final product. It is the physical arrangement of planned industrial operations.

Assessment Activity

Field Visit

Visit a nearby Manufacturing Industry and list out the machines, equipments, furniture, buildings etc. used in the factory and sketch the location of each item on a chart paper.

Need for Plant Layout

- Establishment of new plants
- Expansion of the capacity of existing plants
- Incorporation of latest changes in technology, plant design, equipments etc
- Increasing the efficiency of operations

Assessment Activity

Read the following points and give tick mark on the boxes against to the points which need a decision of plant location.

Increasing the quality of the product	<input type="checkbox"/>
Establishment of a new plant	<input type="checkbox"/>
Decrease the volume of production	<input type="checkbox"/>
Forecast the future demand	<input type="checkbox"/>
Increase the efficiency of operation	<input type="checkbox"/>
Increasing the salary of the employees	<input type="checkbox"/>
Expansion of the capacity of the existing plant	<input type="checkbox"/>
Incorporate latest technology in the production process	<input type="checkbox"/>

Types of Layout

- Product or Line Layout
- Process or Functional Layout
- Combination Layout
- Fixed Position or Location Layout

Product or Line Layout

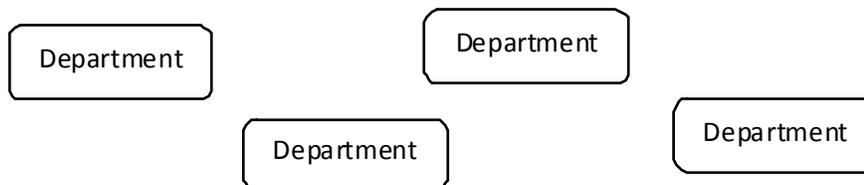
In this layout, the machines and equipments are arranged in one line depending upon the sequence of operations required for the product. The output of one machine becomes input of the next machine. It requires a very little material handling.

It is used for mass production of standardised products.



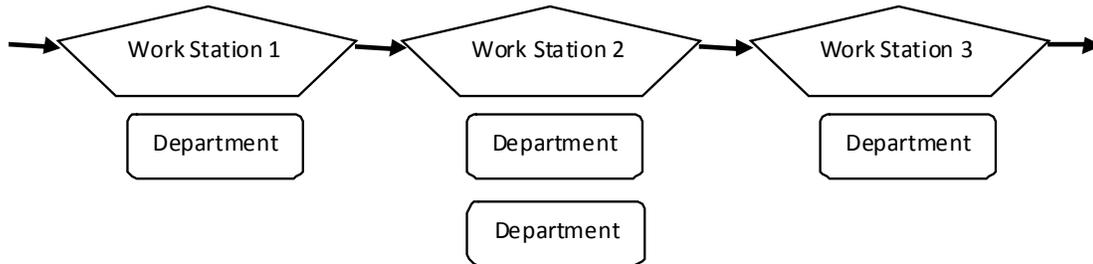
Process Layout

In this layout the machines of a similar type are arranged together at one place. This layout is used for batch production. It is preferred when the product is not standardized and the quantity produced is very small.



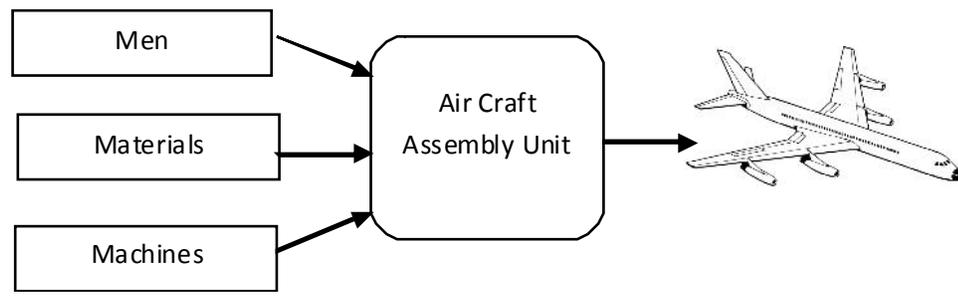
Combined Layout

A combination of process & product layout is known as combined layout. Manufacturing concerns where several products are produced in repeated numbers with no likelihood of continuous production, combined layout is followed.



Fixed Position or Location Layout

Fixed position layout involves the movement of manpower and machines to the product which remains stationary. The movement of men and machines is advisable as the cost of moving them would be lesser. This layout is preferred where the size of the job is bulky and heavy. Example of such type of layout is locomotives, ships, boilers, generators, wagon building, aircraft manufacturing, etc.



Assessment Activity

Suggest a suitable type of layout for the following industries and justify your answers;

- Cashew Industry
- Ship Building
- Car Manufacturing
- Tyre Manufacturing
- Printing Press
- Bus Body Fabrication
- Building Construction
- Readymade Shirts

Aggregate Planning

An organisation can finalise its business plans on the recommendation of demand forecast. Once business plans are ready, an organisation can do backward working from the final sales unit to raw materials required. Thus annual and quarterly plans are broken down into labour, raw material, and working capital requirements over a medium-range period (6 months to 18 months). This process of working out production requirements for a medium range is called aggregate planning. The term aggregate implies that the planning is done for a single overall measure of output or, at the most, a few aggregated product categories. The aim of aggregate planning is to set overall output levels for short term and medium term in considering the fluctuating or uncertainties in demand.

Importance of Aggregate Planning

- Achieving financial goals by reducing overall variable cost and improving the bottom line
- Maximum utilisation of the available production facility
- Provide customer delight by matching demand and reducing wait time for customers
- Reduce investment in inventory stocking
- Able to meet scheduling goals thereby creating a happy and satisfied work force

Aggregate Planning Strategies

There are three types of aggregate planning strategies;

1. **Level Strategy** : Level strategy looks to maintain a steady production rate and work force level. In this strategy, organisation requires a robust forecast demand as to increase or decrease production in anticipation of lower or higher customer demand. Advantage of level strategy is steady work force. Disadvantage of level strategy is high inventory and increased back logs.
2. **Chase Strategy** : Chase strategy looks to dynamically match demand with production. Advantage of chase strategy is lower inventory levels and decreased back logs. Disadvantage is lower productivity, quality and depressed work force.
3. **Hybrid Strategy** : Hybrid strategy looks to balance between level strategy and chase strategy.

Assessment Activity

Identify the type of strategies followed by the following companies.

1. Polo Furniture Pvt. Ltd. forecast a demand of 1500 units per week and they plan to produce 250 units per day uniformly.

2. Tip Top Furniture calculates demand for the next 4 weeks as follows; 1400, 1300, 800 and 900. So they plan to produce 1410 units for the first week, 1305 units for the second week, 802 units for the third week and 905 units for the fourth week.
3. Interior Furnishing Pvt. Ltd. forecast a demand for the next 4 weeks as follows; 1000, 1200, 800, 700. They plan to produce 1200 each for the first two weeks and 750 each for the next two weeks.

Master Production Schedule (MPS)

Aggregate production and capacity plan combine products into product groups, demand into monthly totals and personnel requirements across departments which altogether reflect the top management decisions. Eventually the time comes when individual 'end item' products and services must be scheduled at specific work centres. This is accomplished by master scheduling.

Master scheduling means producing a supply plan, a time table including quantities, to produce specific items or provide specific services within a given time period. Master Scheduling calculates the quantity required to meet demand requirements from all sources.

Assessment Activity

Case Study

Study the following case and suggest suitable solution to the problem faced by the firm.

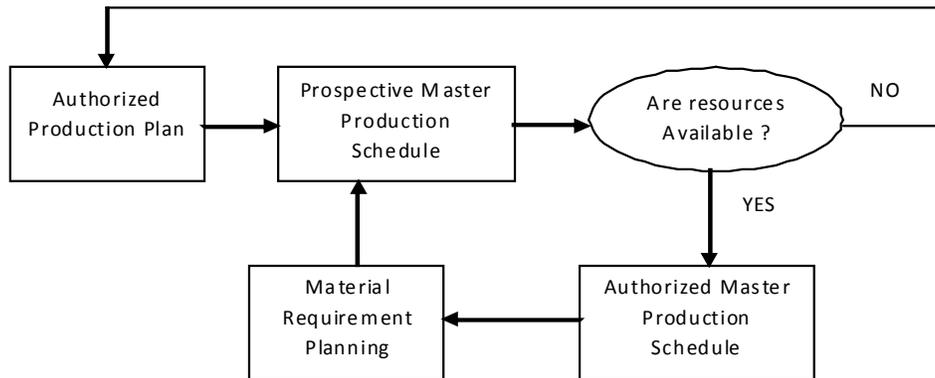
ABC (Pvt) Ltd. is an offset machine manufacturing company at Thiruvananthapuram. In the first week of April, 2016, they had an opening stock of 8 machines and had forecasted a demand of 5 machines per week. They needed a lead time of 1 week for the manufacturing of offset machines. On the first week they had an order of 4 machines and on the second week they had an order of 7 machines. On the third week of April they had an order of 6 machines and on the fourth week they had an order of 4 machines. There was shortage of stock to satisfy the customers and hence some customers cancelled their order and moved to some other suppliers.

Significance of Master Production Scheduling

- It enables marketing to make legitimate delivery commitments to field warehouses and final customers.
- It enables production to evaluate capacity requirements in a more detailed manner.
- It provides the management, opportunity to ascertain whether the business plan and its strategic objectives will be achieved.
- The Master Production Schedule (MPS) is the primary output of the master scheduling process. It is the 'plan' for providing the supply to meet the demand.

Master Production Scheduling Process

- A prospective MPS is created to test whether it meets the schedule with the resources. (eg. Machine capacities, labour, overtime and subcontractors) provided for in the aggregate production plan.
- Operations revise the MPS until it obtains a schedule that satisfies all resource limitations or determines that no feasible schedule can be developed.
- If no feasible schedule can be developed, the production plan must be revised to adjust production requirements or increase authorised resources.
- Once a feasible prospective MPS is accepted, operations use the authorised MPS as input to material requirements planning.
- Operations then determine specific schedules for component production and assembly.
- Actual performance data such as inventory levels and shortages are inputs to the next prospective MPS and the Master Production Scheduling process is repeated.



Developing a Master Production Schedule

The process of developing a master production schedule includes;

1. Calculating the projected on hand inventory.
2. Determining the timing and size of production quantities of specific products.

Calculating Projected on hand inventory

Projected on hand inventory is an estimate of the amount of inventory available each week after demand has been satisfied.

$$\begin{array}{ccccccc}
 \boxed{\text{Projected inventory at the end of this week}} & = & \boxed{\text{Projected on hand inventory at the end of last week}} & + & \boxed{\text{MPS quantity of the current week}} & - & \boxed{\text{Forecasted demand or actual order which ever is higher}}
 \end{array}$$

Assessment Activities

- Geekan Seating Collections (Pvt.) Ltd. produces Executive Chairs and needs to develop an MPS for it. Marketing department has forecasted a demand of 30 chairs for the first week of April. But actual customer orders booked are for 38 chairs. The current on hand inventory is 55 chairs. No MPS quantity is due on week 1. Calculate the projected on hand inventory.

$$\text{Projected inventory} = 55 + 0 - 38 = 17$$

- Study the following table, interpret and make a report

Quantity on Hand 55	APRIL	
	Week 1	Week 2
Forecast	30	30
Customer Orders Booked	38	27
Projected on hand Inventory	17	-13
MPS quantity	0	0
MPS start		
Explanation: Forecast is less than the booked orders in week 1. $\text{Projected on hand inventory} = 55 + 0 - 38 = 17$ Forecast is more than the booked orders in week 1. $\text{Projected on hand inventory} = 17 + 0 - 30 = -13.$		

Determining the timing and size of production quantities of specific products.

The purpose of determining the timing and size of MPS quantities is to maintain a non-negative projected on hand inventory. MPS quantities should be scheduled to cover the shortages. The scheduler adds the MPS quantity to the projected on hand inventory and searches for the next period when a shortage occurs. This shortage signals a need for a second MPS quantity and so on.

Illustrative example of a Master Production Schedule



Assessment Activity

Complete the missing columns of the following Master Production Schedule.

KELACHANDRA RUBBER ROLLERS (PVT.) LTD. KOTTAYAM MASTER PRODUCTION SCHEDULE								
Item: Ruber Sheet Rolling Machine units	Order Policy - 50							
weeks	Lead Time - 2							
	MONTHS							
Quantity on hand 25	JULY				AUGUST			
Weeks	1	2	3	4	5	6	7	8
Forecast	10	10	10	10	10	10	10	10
Customer Orders (booked)	12	8	9	11	15	5	7	13
Projected on hand inventory	13	?	43	?	?	7	?	9
MPS quantity	0	0	50	0	?	0	50	0
MPS start	50	?	0	0	?	0	0	0
Explanation: * the time needed to assemble 150 chairs is 1 week. So MPS start on week 1 to be completed on week 2. ** MPS quantity of 150 is needed to avoid shortage of projected on hand inventory. This is repeated in week 7								

TE Questions

1. Which of the following is a wrong statement;
 - a. Production is concerned with tangible goods.
 - b. Operation is concerned with services.
 - c. Operation is used in a broader sense.
 - d. In management, both production and operation are used in the same meaning.
2. Decisions as to the use of technology is a type of;
 - a. Operational Planning.
 - b. Strategic Planning.
 - c. Operational Planning.
 - d. Middle level planning.
3. The suitable lay out for ship building is;
 - a. Product Lay out
 - b. Process Lay out
 - c. Combination Lay out
 - d. Fixed Position Lay out.
4. Steady Production Rate and Workforce Level - Level Strategy
Dynamic matching of demand with production -
5. What do you mean by production management?
6. What is the importance of production management?
7. Differentiate between production and operation management.
8. Which are the different types of decisions in production management?
9. What do you mean by Strategic decision? Give an example.
10. What do you mean by Tactical decision? Give an example.
11. What do you mean by Operational decision? Give an example.
12. Which are the factors affecting plant location?
13. What do you mean by plant layout?
14. Which are the different types of plant layout?
15. What do you mean by fixed position layout? Give an example.
16. What do you mean by aggregate planning?
17. Which are the strategies used in aggregate planning?

18. What is Master Production Scheduling?
19. Explain the master production scheduling process.
20. Why is master production scheduling significant?
21. What do you mean by Master Production Schedule?
22. How is a Master Production Schedule prepared?
23. Develop a Master Production Schedule from the following;

The forecast is 84 units for the first period and 80 for the second week and 60 units for each of the next three weeks. The starting inventory is 20 units. The company uses a lot size of 50 units and the lead period is 1 week. Committed Orders are as follows:

Week	1	2	3	4	5
Customer Orders	82	82	58	40	20

Extended Activity

Meet some entrepreneurs working in and around your locality. Find out the various factors he/she considered while selecting location for his/ her enterprise. Analyse the same and suggest if he/she could have other better options available for selecting the location of the enterprise.

Unit V

Quality Management

- 5.1. Meaning and Definition of Quality
- 5.2. Dimensions of Quality – Product and Service
- 5.3. Meaning and Concept of Quality Management
- 5.4. Principles of Quality Management
- 5.3. Quality Systems
 - Elements
 - ISO 9000:2000

Introduction

In business, engineering and manufacturing, quality has a pragmatic interpretation as the *non-inferiority* or *superiority* of something; it is also defined as *fitness for purpose*. Quality is a perceptual, conditional, and somewhat subjective attribute and may be understood differently by different people. Quality management ensures quality in all areas of marketing, design, purchasing, production or operations and distribution. The entire organisation should excel on all dimensions of products and services that are important to the customer and to achieve Total Quality Management (TQM).

Learning Outcomes

The learner;

- *Identifies the meaning of quality*
- *Recognizes the definitions of quality*
- *Explains the various approaches to quality*
- *Identifies various approaches to quality*
- *Explains the various approaches to quality*
- *Identifies various approaches to quality*
- *States the meaning of Quality Management*
- *Outlines the concept of Quality Management.*
- *Describes the various principles of quality management.*
- *Explains the meaning of Quality Management System*
- *Identifies the elements of Quality management System*

- *Identifies the concept of ISO standards*
- *Explains the concept of ISO 9000:2000.*

Meaning & Definition of Quality

Quality refers to a parameter which decides the superiority or inferiority of a product or service. It can provide a competitive edge to an organisation. The term “quality” has a relative meaning. It may be seen as the totality of features and attributes that satisfy a customer’s stated and implied needs. In simple words, one can say that a product has good quality when it “complies with the requirements specified by the client”.

Quality is an attribute which differentiates a product or service from its competitors. It plays an essential role in every business. ISO defines quality as “the totality of features and characteristics of a product or service that bear on its ability to satisfy stated or implied needs”.

Now a days, quality standards and strict compliance to it is considered as the key to success in every field of business either in the form of product or service.

Approaches to Quality

Harvard professor David Garvin, in his book ‘Managing Quality’ summarised five principal approaches to defining quality: transcendent, product-based, user-based, manufacturing-based and value-based. Let’s discuss each one of them:

1. **Transcendental view of Quality:** Those who hold transcendental view would say, “I can’t define it, but I know when I see it.” Advertisers are fond of promoting products in these terms. “Where shopping is a pleasure” (super market), “We love to fly and it shows” (airline), and “It means beautiful eyes” (cosmetics) are examples.
2. **Product-based view of Quality:** Product based definitions are different. Quality is viewed as quantifiable and measurable characteristics or attributes. For example, durability or reliability can be measured (e.g. mean time between failure, fit and finish), and the engineer can design to that benchmark. Quality is determined objectively. Although this approach has many benefits, it has limitations as well. Where quality is based on individual taste or preference, the benchmark for measurement may be misleading.
3. **User-based view of Quality:** User based definitions are based on the idea that quality is an individual matter, and products that best satisfy their preferences (i.e. perceived quality) are those with the highest quality. This is a rational approach but leads to two problems. First, consumer preferences vary widely, and it is difficult to aggregate these preferences into products with wide appeal. This leads to the choice

between a niche strategy or a market aggregation approach which tries to identify those product attributes that meet the needs of the largest number of consumers.

4. **Manufacturing-based view of Quality:** Manufacturing-based definitions are concerned primarily with engineering and manufacturing practices and use the universal definition of “conformance to requirements.” Requirements, or specifications, are established design, and any deviation implies a reduction in quality. The concept applies to services as well as products.
5. **Value-based view of Quality:** Value-based quality is defined in terms of costs and prices as well as a number of other attributes. Thus, the consumer’s purchase decision is based on quality (however it is defined) at the acceptable price.

Dimensions of Quality

Eight dimensions of product quality management can be used at a strategic level to analyse quality characteristics. The concept was defined by David Garvin. Some of the dimensions are mutually reinforcing, where as others are not. Improvement in one may be at the expense of others. Understanding the trade-offs desired by customers among these dimensions can help to build a competitive advantage. Garvin’s eight dimensions can be summarised as follows:

1. **Performance:** Performance refers to a product’s primary operating characteristics. This dimension of quality involves measurable attributes; brands can usually be ranked objectively on individual aspects of performance.
2. **Features:** Features are additional characteristics that enhance the appeal of the product or service to the user.
3. **Reliability:** Reliability is the likelihood that a product will not fail within a specific time period. This is a key element for users who need the product to work without fail.
4. **Conformance:** Conformance is the precision with which the product or service meets the specified standards.
5. **Durability:** Durability measures the length of a product’s life. When the product can be repaired, estimating durability is more complicated. The item will be used until it is no longer economical to operate it. This happens when the repair rate and the associated costs increase significantly.
6. **Serviceability:** Serviceability is the speed with which the product can be put into service when it breaks down, as well as the competence and the behaviour of the service person.

7. **Aesthetics:** Aesthetics is the subjective dimension indicating the kind of response a user has, to a product. It represents the individual's personal preferences.
8. **Perceived Quality:** Perceived Quality is the quality attributed to a good or service based on indirect measures.



Eight dimensions of quality

Service Quality

Service providers want to know what customers (internal or external) care about. Service quality is a good guess. After extensive research, Valerie Zeithaml, A. Parasuraman and Leonard Berry found five dimensions, customers use when evaluating service quality. They named their survey instrument SERVQUAL. The five SERVQUAL dimensions are:

- **TANGIBLES**-Appearance of physical facilities, equipment, personnel, and communication materials.
- **RELIABILITY**-Ability to perform the promised service dependably and accurately.
- **RESPONSIVENESS**-Willingness to help customers and provide prompt service.
- **ASSURANCE**-Knowledge and courtesy of employees and their ability to convey trust and confidence.
- **EMPATHY**-Caring, individualised attention the firm provides its customers.

Meaning and Concept of Quality Management

Quality management is the act of overseeing all activities and tasks needed to maintain a desired level of excellence. This includes creating and implementing quality planning and assurance, as well as quality control and quality improvement. It is also referred to as total quality management (TQM).

Quality management ensures that an organisation, product or service is consistent. It has four main components: quality planning, quality control, quality assurance and quality improvement. Quality management is focused not only on product and service quality, but also on the means to achieve it.

Quality assurance (QA) is a broad concept that focuses on the entire quality system including suppliers and ultimate consumers of the product or service. It includes all activities designed to produce products and services of appropriate quality.

Quality control(QC) has a narrower focus than quality assurance. Quality control focuses on the process of producing the product or service with the intent of eliminating problems that might result in defects.

Assessment Activity

Complete the components of Quality Management.



Principles of Quality Management

1. **Customer focus** : Organisations depend on their customers and therefore, should understand current and future customer needs. They should meet customer requirements and strive to exceed customer expectations.

Key Benefits:

- Increased revenue and market share obtained through flexible and fast responses to market opportunities
- Increased effectiveness in the use of the organisation's resources to enhance customer satisfaction
- Improved customer loyalty leading to repeat business.

2. **Leadership** : Leaders establish unity of purpose and direction of the organisation. They should create and maintain the internal environment in which people can become fully involved in achieving the organisation's objectives.

Key Benefits:

- People will be motivated towards the organisation's goals and objectives
- Activities are evaluated, aligned and implemented in a unified way
- Mal-communication between levels of an organisation will be minimised.

- 3 . **Involvement of people**: People at all levels are the essence of an organisation and their full involvement should be focused for the benefit of the organisation.

Key Benefits:

- Motivated and committed people within the organisation
- Innovation and creativity in furthering the objectives of the organisation.
- People became accountable for their own performance
- People participate and contribute to continual improvement.

- 4 . **Process approach** : A desired result is achieved more efficiently when activities and related resources are managed as a process.

Key Benefits

- Lower costs through effective use of resources
- Improved, consistent and predictable results
- Focused and prioritised improvement opportunities.

- 5 . System approach to management** : Identifying, understanding and managing interrelated processes as a system contributes to the effectiveness and efficiency of the organisation in achieving its objectives.

Key Benefits:

- The desired result will be best achieved by Integration and alignment of the processes.
- Ability to focus effort on the key processes
- Providing confidence to interested parties as to the consistency, effectiveness and efficiency of the organisation.

- 6 . Continual improvement** : Continual improvement of the organisation's overall performance should be a permanent objective of the organisation.

Key Benefits:

- Performance advantage through improved organisational capabilities
- Alignment of improvement activities at all levels to an organisation's strategic intent
- Flexibility to react quickly to opportunities.

- 7 . Factual approach to decision making** : Effective decisions are based on the analysis of data and information

Key Benefits:

- Informed decisions
- An increased ability to demonstrate the effectiveness of past decisions based on factual records
- Increased ability to review, challenge and, change opinions and decisions if necessary.

- 8. Mutually beneficial supplier relationships:** An organisation and its suppliers are interdependent, and mutually beneficial relationship enhances the ability of both to create value.

Key Benefits:

- Increased ability to create value for both parties
- Flexibility and speed of joint responses to changing market or customer needs and expectations
- Optimisation of costs and resources.

Quality System

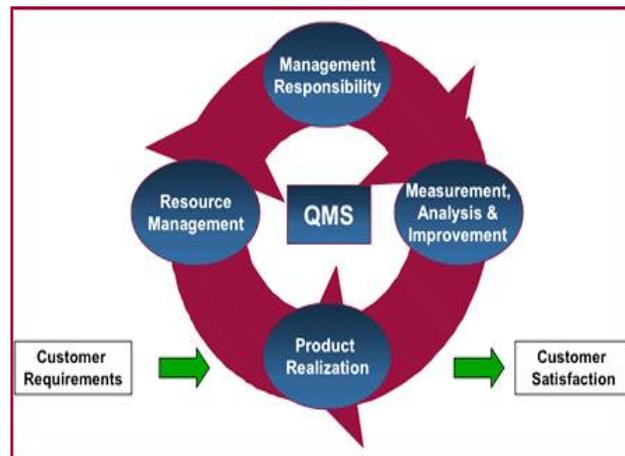
It is the system that an organisation uses to manage the quality of their services or products. Quality management system is only one type of management systems; other examples include financial management systems, safety management systems and environmental management systems.

The definition of a quality system from ISO (the International Organisation for Standardisation) is ‘the management system used to direct and control an organisation with regard to quality’.

Elements of a Quality Management System

The ISO 9001 standard is a model of a quality system, describing the processes and resources required for registration of a company’s quality system. A brief summary of the key elements are detailed below.

- **QMS** - Document processes necessary to ensure product or service is of high quality and conforms to customer requirements.
- **Management Responsibility** - Provide a vision. Show commitment. Focus on the customer. Define policy. Keep everyone informed.
- **Resource Management** - Assign the right person to the job. Create and maintain positive work space.
- **Product Realisation** - Clearly understand customer, product, legal and design requirements. Ensure that the specifications are followed. Check your suppliers.
- **Measurement, Analysis & Improvement** - Identify current and potential problems. Monitor and measure customer satisfaction. Perform internal audits. Fix problems.



International Organisation for Standardisation (ISO) :

International Organisation for Standardisation (ISO) is an international standard-setting body composed of representatives from various national standards organisations. It is an independent, non-Governmental international organisation with a membership of 162 national standards bodies. Through its members, it brings together experts to share knowledge and develop voluntary, consensus-based, market relevant International Standards that support innovation and provide solutions to global challenges.

ISO standards are documented rules and guidelines for implementing a quality system into a company. Specific technical specifications and/or other specific criteria may also be included depending on the standard, a company select.

ISO 9000 : 2000

ISO first published its quality standards in 1987 and later revised them in 1994. They were later revised in 2000. The quality standards of 1994 formed the ISO 9000 series. The series comprised ISO 9000, ISO 9001, ISO 9002, ISO 9003 and ISO 9004. Whereas ISO 9000 and ISO 9004 are only established guidelines for operations, ISO 9001, ISO 9002 and ISO 9003 were well defined standards.

The new ISO 9000:2000 has done away with the previous ISO 9002 and ISO 9003 standards. The new series consists of:

- ISO 9000:2000 - describes the fundamentals of a quality management system and specifies terminology. It presents guidelines.
- ISO 9001:2000 - specifies requirements for a quality management system.
- ISO 9004:2000 - guidelines for performance improvement.

Most companies in the world today want to do business with companies and organisations that have ISO 9000 certification. The certification ensures that the company irrespective of language barriers, cultural and social differences, and technological variations has a quality system that meets uniform standards. The ISO 9000:2000 is the only standard that carries third party certification. A third party called Registrar, accredited by national body, is the only authorised entity that can award an ISO 9000 certification. ISO 9000 certification is only awarded after he is satisfied that the organisation meets the ISO 9001 requirements. This certification is recognised worldwide.

Assessment Activity

List out the various types of quality standards suitable for different types of products or services.

Quality standards	Products/Services
AGMARK	?
?	For eco-friendly products
?	For precious metals like gold, platinum etc
?	Quality Management System

TE Questions

- A parameter which decides the superiority or inferiority of a product or service is;
(a) Quantity (b) Value (c) Price (d) Quality
- The five SERVQUAL dimensions does not include;
(a) Tangibles (b) Consistency (c) Empathy (d) Assurance
- Complete the series
Fitness for purpose/Superiority of something - Quality
System that an organisation uses to manage the quality of their services/products
.....
- What you mean by user-based view of quality?
- Briefly explain the elements of Quality Management System.
- Write a short note on ISO 9000:2000 quality standards?
- Explain the various dimensions of Quality with the help of a diagram.
- Discuss the various principles of Quality Management.

Extended activities

- Visit the web sites of different companies and prepare a list of companies and the quality certification they have attained.
- Conduct a survey among people of your locality about the awareness of different quality standards.

Unit VI

Measures of Central Tendency

- 6.1. Meaning and Significance of Central Tendency
- 6.2. Qualities of a good average
- 6.3. Types of Average
- 6.4. Simple Arithmetic Mean – Individual Observation, Discrete Series, Continuous Series.
- 6.5. Weighted Arithmetic Mean
- 6.6. Combined Arithmetic Mean
- 6.7. Correction in Mean
- 6.8. Median - Individual Observation, Discrete Series, Continuous Series.
- 6.9. Determination of Median Graphically.
- 6.10. Partition Values – Quartiles, Deciles and Percentiles
- 6.11. Quartiles - Individual Observation, Discrete Series, Continuous Series.
- 6.12. Percentiles - Individual Observation, Discrete Series, Continuous Series.
- 6.13. Mode - Individual Observation, Discrete Series, Continuous Series.
- 6.14. Locating Mode Graphically
- 6.15. Comparison of mean, median and mode

Introduction

Statistics plays an important role in managerial decision making. Business managers use statistics to present and describe data and information properly, to draw conclusions about large population with samples and to make reliable forecast about a business activity. To describe the data condensation is necessary. This is because a large number of big figures are difficult to analyse. Therefore, in order to reduce the complexity of data and to make them comparable, it is necessary that various data are reduced to a single value. This can be done by using central tendency or averages which summarises the whole data in single value. The word average is commonly used in day-to-day life. eg. average production, average expenditure, average income, average marks obtained by students in a class etc. The concept of measure of central tendency is an important tool in the statistics. The measure of central tendency is also called Averages or Measure of location. This unit gives an idea on the concept of averages, qualities of good average and different types of average. It helps the learners to calculate different types of average.

Learning Outcomes

The learner:

- *Identifies the concept of Average*
- *Explains requisites of a good average*
- *Recognises the concept of mean*

- *To calculate Mean for different series*
- *Identifies the meaning of weighted arithmetic mean*
- *Computes the weighted arithmetic mean*
- *Compute combined Mean*
- *Rectifies incorrect mean*
- *Recognises the concepts of the term median*
- *Computes the median in different situations*
- *Identifies the concepts of mode*
- *Recognises the concepts of locating median and mode graphically*
- *Lists out the partition values*
- *Computes the quartiles, deciles and percentiles*
- *Compares Mean, Median and Mode.*
- *Selects appropriate average to be used on different cases*

Measures of central tendency: Meaning

Values of a statistical series shows a tendency to concentrate around a particular central value. This tendency is called central tendency. In other words, the central tendency is the extent to which all the data values group around a typical or central value. The typical or central value is called ‘average.’

“An average is a significant single expression representative of the whole distribution”. A measure of central tendency will represent whole of the distribution ie. measure of central tendency summarises data in a single value which represent the entire data.

Importance of Measures of central tendency

- a. To find representative value : Average is a single value which can represent the entire distribution.
- b. To condense data : Collected and classified figures are vast. To condense these figures, we use averages.
- c. To make comparison : To make comparison of two or more distributions , we have to find the representative values of these distributions. These representative values are found with the help of measure of the central tendency
- d. Helpful in further statistical analysis : Many techniques of statistical analysis like measures of dispersion, measures of correlation, Index numbers etc are based on measures of central tendency.

Qualities of a good average

For an ideal measure of central tendency, following qualities are necessary:

- It should be rigidly defined
- It should be representative of the entire data
- It should be based of all observation
- It should be easily calculated
- It should be capable of easy interpretation.
- It should be capable of further mathematical calculation
- It should not be influenced by the extreme value

Types of Averages

There are various types of measures of central tendency or Averages. Most important among them are:

- Arithmetic Mean
- Median
- Mode

Assessment Activity

Following table showing the land holding of 50 farmers in village.

Land holdings in acre	No. of families
2	6
3	8
4	10
5	1
6	11
7	9
8	5

Anil, one of the farmers holds 4 acres of land. Evaluate his economic condition by comparing his size of land with the size of land holdings of other farmers.

For this, you may like to see through inspection, if the land owned by Anil is –

- above average in ordinary sense? (see Arithmetic Mean)
- above the size of the what half the farmers own?(see the median)
- above what most of the farmers own? (see the Mode)

Arithmetic Mean

This is the most commonly used measure of central tendency. It is defined as the sum of the values of all items divided by the number of items. It is denoted by \bar{X} .

Arithmetic mean may be of two types; Simple Arithmetic Mean and weighted Arithmetic Mean.

Simple Arithmetic Mean

1. Individual series

Arithmetic mean for Individual series is the sum of all items in a series divided by the total number of item

$$\bar{X} = \frac{\sum x}{N}$$

Example

Calculate Arithmetic mean from the data showing daily income of the families in a village
250,,275,280,300,500,250, 290,350,400,375

$$\text{Solution : } \sum X = 250 + 275 + 280 + 300 + 500 + 250 + 290 + 350 + 400 + 375 = 3270 ;$$

$$N = 10$$

$$\text{Mean} = 3270/10 = 327$$

2. Discrete Series

In case of discrete series, frequency against each of the item is multiplied by the value of the item. The value so obtained are summed up and divided by the total number of frequencies.

In this series, Mean may be computed by applying (i) Direct method or (ii) Short-cut method.

Direct Method : under this method, the formula for computing Mean is

$$\bar{X} = \frac{\sum fX}{N}$$

where f = frequency ; X = the variable ; N= total of frequency ie. $\sum f$

Short cut method :

In this method, calculation can be simplified by using Assumed mean. Hence according to

this method , $\bar{X} = A + \frac{\sum fd}{N}$ where A = assumed mean

$$d = (\bar{X} - A); \quad N = \sum f$$

Example

Marks obtained by students in a class are given below

Marks	10	20	30	40	50	60	70	80
No. of students	12	20	18	18	11	9	8	4

- * How do you calculate average marks in this series?
- * what is the need of using two methods?
- * Whether the answers under two methods are one and same?

Solution : (i) Direct method

Marks(X)	No. of students(f)	fX
10	12	120
20	20	400
30	18	540
40	18	720
50	11	550
60	9	540
70	8	560
80	4	320
Total	100	3750

$$\text{Mean} = \frac{\sum fX}{N} = \frac{3750}{100} = 37.5 \quad \text{Average mark is } 37.5$$

Solution : (ii) Short –cut method

Let us assume 40 as Assumed Mean=(A)

Marks(X)	No. of students(f)	d (X – 40)	fd
10	12	-30	-360
20	20	-20	-400
30	18	-10	-180
40	18	0	0
50	11	10	110
60	9	20	180
70	8	30	240
80	4	40	160
Total	100		- 250

$$\bar{X} = A + \frac{\sum fd}{N} = 40 + (-250)/100 = 40 + (-2.5) = 37.5$$

3. Continuous Series

In continuous series, class intervals are given. The process of calculating arithmetic mean is same as that of a discrete series. The only difference is that the mid-points of various class intervals are taken. Here, arithmetic mean may be computed by applying any of the following methods.

- a. Direct method b. Short-cut method

- a. **Direct method** : In this method, each class frequency is multiplied by the mid-value of the class, the products added and the total of the product divided by the number of items.

$$\bar{X} = \frac{\sum fm}{N}$$

where m= mid-value ; f = frequency of each class ; N = the total of frequency

b. Short-cut method : Under short cut method the calculations are based on the deviations taken from the assumed mean .

$$\bar{X} = A + \frac{\sum fd}{N} \text{ where } A = \text{assumed mean; } d = (m - A); N = \text{Total of frequency}$$

Assessment Activity

The following table showing marks of 70 students in a class

Marks X	No. of students-f
0 -10	5
10 - 20	12
20 - 30	15
30 - 40	25
40 - 50	8
50 - 60	3
60 - 70	2
	70

- * What is the main difference between calculation of mean in the continuous series and discrete series?
- * Compute arithmetic mean under two methods in continuous series

Merits of Arithmetic Mean

1. It is simple to understand and easy to calculate
2. It is rigidly defined
3. It is based on all the values of the series
4. It is more reliable for comparison
5. It can be calculated without arranging the data in any form
6. It is capable of further mathematical treatment

Demerits of Arithmetic mean

1. It is very much affected by the extreme values of the variable
2. It is difficult to calculate in open end classes
3. It is not suitable for averaging ratios and percentages
4. It can be a value which does not exist in the series
5. It cannot be calculated in the absence of any of the item

Weighted Arithmetic Mean

In the calculation of simple average, each item of the series is considered as equally important. But there are certain cases where values are to be given appropriate weights. For example, to compute the average cost of food items of a person in Kerala, more weight should be given to rice than wheat. In such cases simple average is not suitable, hence we compute weighted average.

The formula for computing weighted Arithmetic Mean is

$$\bar{X}^w = \frac{\sum WX}{\sum W}$$

where \bar{X}^w = Weighted arithmetic mean; W = weights ; X = the variable

Assessment Activity

Find out weighted arithmetic mean from the following data

Group	Index no- X	Weights- W
Food	300	40
Fuel	220	10
Cloth	210	8
House rent	160	12
Miscellaneous	200	14

Combined Mean

If a statistical series consists of two or more component series, and mean and number of each component series are known, we can compute mean of the entire series. That mean is called combined Mean .

When two or more distributions are given with their number of items and arithmetic means ,we can calculate the combined mean as follows;

$$\bar{X}_{12} = \frac{\bar{X}_1 N_1 + \bar{X}_2 N_2}{N_1 + N_2}$$

If we have to find out the combined mean of three or more distributions, the above formula can be extended as follows

$$\bar{X}_{123} = \frac{X_1 N_1 + X_2 N_2 + X_3 N_3 + \dots}{N_1 + N_2 + N_3 + \dots}$$

where X_1 = Mean of first distribution; X_2 = Mean of second distribution; N_1 = No . of items in the first distribution ; N_2 = No. of the second distribution and so on.

Assessment Activity

The Mean age of 40 students is 16 years and the mean age of another group of 60 students is 20 years. Find out the mean age of 100 students combined together.

Correction in mean

While calculating mean, wrong items crept in due to mistakes or oversight and thereby we get wrong mean. In order to correct such mistakes we have to deduct incorrect values and add correct values to the incorrect total (incorrect Mean \times number of items), then find correct mean.

Following formula is applied for the correction of mean.

$$\text{Total value of the observation } (\sum X) = \bar{X} \times N \text{ (incorrect total value)}$$

$$\text{correct } \sum X = \text{Incorrect total value} - \text{wrong item} + \text{correct item}$$

$$\text{Correct Mean} = \text{correct total value} / N$$

Example

The average marks secured by 50 students was 44 . Later on it was discovered that score of 36 was taken as 56. Correct the mean.

Solution : Total value of observation (incorrect value) = $44 \times 50 = 2200$

$$\text{Correct total value} = 2200 - 56 + 36 = 2180 ; \quad \text{correct Mean} = \frac{2180}{50} = 43.6$$

Assessment Activity

Examine that the sum of the deviations of the items from the average is always equal to Zero, ie “ $(X - \text{Mean}) = 0$ and Arithmetic mean is affected by extreme values from the following data.

X : 4 8 12 14 16 20 24

Replace the value 4 by 74, what happens to the arithmetic mean?

Median

Arithmetic mean is affected by the values of the extreme items. It cannot be calculated for qualitative observation like honesty, intelligence, blindness etc. Moreover, if a frequency distribution includes open end class, arithmetic mean does not exist. In order to avoid these drawbacks, other measures of central tendency, median or mode is used. Median is the middle value when the data set is arranged in order of the magnitude.

“Median of a series is the value of that item, actual or estimated when series is arranged in order of magnitude which divides the distribution into two parts”. - Prof.H.Secret.

Thus median is the value of middle most observation in a data. It is that value of the variable which divides the distribution into equal parts, one part comprises all values greater than or equal to the median and the other comprises all values less than or equal to it. It is also called as positional average.

Uses of Median

Median is used

1. to calculate the qualitative data like intelligence, honest etc
2. to calculate the relative standing of the individual in a certain class or society.

Computation of Median

A. Individual series

The median can be easily computed by sorting the data in ascending or descending order. Then Median is computed by the formula;

Median = Size of $(N + 1 / 2)^{\text{th}}$ item

Example

Calculate Median from the following

15, 20, 25, 28, 16, 18, 17, 9, 11

Solution

1. Arrange the data in ascending or descending order?
2. Use the formula , $M = N+1/2^{\text{th}}$ item.

The value of the item thus obtained will be median , here 5th item is median ie. =17

B. Discrete series

Arrange the data(X) in ascending or descending order. Then find out the cumulative frequencies. Use the following formula

Median = Size of $(N + 1) / 2^{\text{th}}$ item

Assessment Activity

Calculate Median from the following data

Variable(X)	Frequencies
5	18
10	16
15	14
20	9
25	13
30	8
	N = 78

C. Continuous series

In case of continuous series, we have to locate the median class where $N/2^{\text{th}}$ item (not $(N+1)/2$ th item) lies. Median can then be obtained as follows;

Median = $L + \frac{(\frac{N}{2} - cf)}{f} \times i$ where L = lower limit of median class;
cf = cumulative frequency of the class just preceding the median class; f = simple frequency of the median class ; i = the class interval of the median class.

Assessment Activity

Following data relates to daily wages of persons working in a factory.

Compute the median daily wages.

Daily wages	No. of workers
20 – 25	14
25 – 30	28
30 – 35	33
35 – 40	30
40 – 45	20
45 – 50	15
50 – 55	13
55 – 60	7

You should remember that Median, as a measure of central tendency, is not sensitive to all the values in the series. It concentrates on the values of the central values of the data

Assessment Activities

Find Mean and median for all four values of the series.

What do you observe ?

Series 1 values(x) 10 13 17 22 18

Series 2 values 10 13 17 22 48

Series 3 Values 10 13 17 22 448

Series 4 Values 10 13 17 22 4448

Is median affected by extreme values ?

Is median a better method than mean

Merits and demerits of Median

Merits

1. It is especially useful in the case of open-end classes
2. Its value is not affected by the presence of extreme values
3. It is the most appropriate average in dealing with qualitative data like intelligence, honesty etc.
4. It is useful in measuring dispersion and skewness
5. It can be located graphically

Demerits

1. It may not be representative of series in many cases e.g. in a series 14 15 55 62 67, median is 55 which is not a true representative of the data.
2. It is not based on all the observation of the data.
3. It is not capable of further Mathematical operations.
4. It is affected by sampling fluctuations. Thus, if class-intervals are not uniform, the value of median becomes inappropriate.

Determination of Median graphically

Median can also be calculated with the help of Cumulative frequency Curve or Ogive

The following steps will be taken to calculate median with the help of Ogive

1. Draw a less than Ogive or more than Ogive of the series.
2. Calculate size of $N/2$ th item and locate this point in Y-axis.
3. From $N/2$ th item distance, draw a straight line parallel to X-axis and let it meet the Ogive curve and intersect it.
4. From the point of intersection, draw a perpendicular line to X-axis. The point where the line meets the X-axis, gives the value of median.

Assessment Activity

Draw the cumulative frequency curve from the following data and find out the median.

Marks	No. of Students
40-45	4
45-50	6
50-55	8
55-60	10
60-65	7
65-70	6
70-75	5
75-80	3
80-85	1

Hints: In order to calculate median by cumulative frequency curve, we have draw 'More than Ogive' or 'Less than Ogive'.

Compute size of $N/2$ th item and locate this point on Y- axis, ie. 25th item

Median = 58.5

Mode

Mode is defined as the value which occurs maximum number of times in a series. Mode is the most frequently observed data value. So it is value with highest frequency .

“the value occurring most frequently in a series(or group) of items and around which the items are distributed most densely is called Mode”. - Prof. Zizek

Uses of Mode

Sometimes, you may be interested in knowing the most typical value of the series or the value around which maximum concentration of items occurs. For example, a manufacturer would like to know the size of shoes that has maximum demand, style of the shirt that is more frequently demanded, to estimate crop yield etc. Similarly, in case of election results, a political party with largest votes(i.e., maximum frequency) is considered as representative. Here , Mode is the most appropriate measure.

Calculation of Mode

A. Individual series

In an Individual series mode can be the value which occurs maximum number of times in a series.

Example 41, 42, 45, 44, 45, 48, 50, 45, 47, 50, 56

Solution : By observation, we notice that 45 occurs 3 times in the series. Thus 45 is Mode.

When there are two or more values, having the same maximum frequency, mode is said to be ill-defined. In such case, mode is calculated by the following formula.

$$\text{Mode} = 3 \text{ Median} - 2 \text{ Mean}$$

B. Discrete series

In discrete series , value with the highest frequency is taken as mode

Example Find mode from the following;

X	f
10	28
20	73
30	115
40	205
45	110
50	88
55	37

Solution : We observe that maximum frequency is 205. Hence, mode is 40.

Grouping Table Method

In some cases, it is possible that the value having the highest frequency may not be the mode. An error of judgment is possible where the difference between the maximum frequency and the frequency preceding it or succeeding it is very small. In such a case, we use another method and that is known as Grouping Method.

C. Continuous series

In a continuous series mode lies in the class having the highest frequency. Either by Grouping and analysis tables or by inspection, we have to find out Model Class. Then apply the following formula

$$\text{Mode} = L + \frac{D_1}{D_1 + D_2} \times i$$

where L = lower limit of the model class ; D_1 = The difference between the frequency of the model class and the frequency of the pre-model class(ignoring signs) ; D_2 = the difference between the frequency of the model class and the frequency of the post-model class ; i = the class intervals of the model class.

Example

Calculate the Mode of marks obtained by 10 students which is given below

Marks	No.of students
0 – 10	3
10 – 20	5
20 – 30	7
30 – 40	10
40 – 50	12
50 – 60	15
60 – 70	12
70 – 80	6
80 – 90	2
90 – 100	8

Solution

Highest frequency is 15; therefore model class = 50 – 60.

$$\text{Mode} = L + \frac{D_1}{D_1 + D_2} \times i = 50 + \frac{3}{3+3} \times 10 = 50 + 5 = 55$$

Assessment Activity

A readymade garments unit, making shirts for males only, wants to know the most popular size of shirt. Which average will be most appropriate for it?

Location of Mode Graphically

Mode can be located graphically with the help of histogram.

- Steps:
1. Draw a histogram of the given data
 2. Draw two lines diagonally in the inside of the model class bar, starting from each corner of the bar to the upper corner of the adjacent bar
 3. Then draw a perpendicular line from the point of intersection to the X-axis, which gives us the model value.

Merits and Demerits of Mode

Merits

1. Mode is the most representative value of the distribution
2. It is not affected by the extreme values
3. It can also be determined graphically
4. It can be used to describe the qualitative aspects

Demerits

1. Mode is not based on all observations
2. In the case of bi-modal series mode cannot be determined
3. It cannot be manipulated mathematically

Partition Values

Median divides a series into two equal parts. Similarly, we can locate the values which divide the series into four, ten, hundred parts. Quartiles, Deciles and percentiles are such measures. It should be noted that quartiles, deciles etc are not averages but measures of dispersion.

Quartiles

Quartiles divided a series into four equal parts. Thus, for any distribution, there are 3 quartiles denoted as Q_1 , Q_2 and Q_3 .

Q_1 is known as first or lower quartile which divides the distribution in such a way that one-fourth of total observations fall below it and three-fourth are above it.

Q_2 is known as median or middle quartiles. It is also called second quartiles.

Q_3 is known as upper quartiles or third quartiles. It divides the distribution in such a way that three-fourth of total observation fall below it and one-fourth above it.

The methods of locating quartiles is the same as discussed for median. In the individual and discrete series, Q_1 is found by determining the size of $(N+1)/4^{\text{th}}$ items and Q_3 is found by determining the size of $3(N+1)/4^{\text{th}}$ item.

For continuous series, we first locate the classes in which the quartiles lie by the following formula

$Q_1 = N/4^{\text{th}}$ item and $Q_3 = 3N/4^{\text{th}}$ item. After finding the size of the item of Q_1 and Q_3 , apply the following formula to determine the value of Q_1 and Q_3 .

$$Q_1 = L + \frac{\frac{N}{4} - cf}{f} \times i \quad \text{and} \quad Q_3 = L + \frac{\frac{3N}{4} - cf}{f} \times i$$

Where L = the lower limit of the quartile class ; f = frequency of the class in which the quartile lies

i = the width of the quartile class intervals ; cf = cumulative frequency of the class in which quartile lies.

Deciles

It divides the distribution into ten equal parts. For any series there can be nine deciles i.e. D_1 to D_9 . The value of the 5th deciles (D_5) is same as Q_2 or the Median.

In individual and discrete series the value of deciles is the size of $N+1/10^{\text{th}}$ item.

e.g., $D_4 = 4N+1/10^{\text{th}}$ item, $D_6 = 6N+1/10^{\text{th}}$ item.

But in continuous or class interval series, the value of the deciles is the size of $N/10^{\text{th}}$ item. e.g., $D_4 = 4N/10^{\text{th}}$ item, $D_6 = 6N/10^{\text{th}}$ item and then calculate the value of the deciles with the following formulae;

$$D_1 = L + \frac{\frac{N}{10} - cf}{f} \times i ; \quad \text{or} \quad D_3 = L + \frac{\frac{3N}{10} - cf}{f} \times i ; \quad \text{or} \quad D_9 = L + \frac{\frac{9N}{10} - cf}{f} \times i$$

Where L = lower limit of the class in which the deciles lie.; cf = cumulative frequency of the class preceding the class in which deciles lie; f = the frequency of the class in which the deciles lie; i = width of the class in which deciles lie.

Percentiles

Percentile divides the series into hundred equal parts. For any series, there can be 99 percentiles P_1 to P_{99} .

In individual and discrete series, the value of the percentile (say P_1) is the size of $N+1/100^{\text{th}}$ item. e.g., the value of P_{55} = size of the $55N+1/100^{\text{th}}$ item.

For continuous series, the value of the percentile is the size of the $N/100^{\text{th}}$ item. e.g., the value of P_{60} = $60N/100^{\text{th}}$ item and then calculate the value of the percentile with the help of the following formulae

$$P_1 = L + \frac{\frac{N}{100} - cf}{f} \times i \quad \text{or} \quad P_{99} = L + \frac{\frac{99N}{100} - cf}{f} \times i \quad \text{so on...}$$

Where L = lower limit of the class in which the percentile lies.; cf = cumulative frequency of the class preceding the class in which percentile lies; f = the frequency of the class in which the percentile lies; i = width of the class in which percentile lies.

Example-1

Calculate Q_1 , Q_3 , D_3 , D_7 , P_{35} and P_{80} from the following marks obtained by 19 students
Marks : 18, 20, 25, 17, 9, 11, 23, 37, 38, 42, 36, 35, 8, 6, 11, 21, 20, 41, 35

Solution

First of all, arrange the marks in ascending order

Marks : 6, 8, 9, 11, 11, 17, 18, 20, 20, 21, 23, 25, 35, 35, 36, 37, 38, 41, 42.

$Q_1 = N+1/4^{\text{th}}$ item = $19+1/4 = 5^{\text{th}}$ item; value of the 5^{th} item = 11

$Q_3 = 3N+1/4^{\text{th}}$ item = $3(19+1)/4^{\text{th}}$ item = 15^{th} item ; value of the 15^{th} item = 36

$D_3 = 3N+1/10^{\text{th}}$ item = $3(19+1)/10 = 6^{\text{th}}$ item; value of the 6^{th} item = 17

$D_7 = 7N+1/10^{\text{th}}$ item = $7(19+1)/10 = 14^{\text{th}}$ item ; value of the 14^{th} item = 35

$P_{35} = 35N+1/100^{\text{th}}$ item = $35(19+1)/100 = 7^{\text{th}}$ item; value of the 7^{th} item = 18

$P_{80} = 80N+1/100^{\text{th}}$ item = $80(19+1)/100 = 16^{\text{th}}$ item; value of the 16^{th} item = 37

Example 2

From the following series calculate Q_1 , Q_3 , D_6 , P_{47} :

Variable	Frequency
5	16
10	18
15	22
20	21
25	24
30	14
35	11
40	9

Solution

Variable	Frequency	cf
5	16	16
10	18	34
15	22	56
20	21	77
25	24	101
30	14	115
35	11	126
40	9	135

$$Q_1 = N+1/4^{\text{th}} \text{ item} = 135+1/4^{\text{th}} \text{ item} = 34^{\text{th}} \text{ item} = 10$$

$$Q_3 = 3(N+1)/4^{\text{th}} \text{ item} = 3(135+1)/4^{\text{th}} \text{ item} = 102^{\text{th}} \text{ item} = 102 \text{ lies in } 115^{\text{th}} \text{ item} = 30$$

$$D_6 = 6N+1/10^{\text{th}} \text{ item} = 6(135+1)/10^{\text{th}} \text{ item} = 81.6^{\text{th}} \text{ item lies in } 101 = 25$$

$$P_{47} = 47N+1/4^{\text{th}} \text{ item} = 47(135+1)/100^{\text{th}} \text{ item} = 63.92^{\text{th}} \text{ item lies in } 77 = 20$$

Assessment Activity

Calculate Median, quartile one, 3rd deciles and 53rd percentile from the following.

Marks	No. of students
0 – 10	16
10 – 20	14
20 – 30	23
30 – 40	17
40 – 50	7
50 – 60	3

Hints: Median = value of $N/2^{\text{th}}$ item = $80/2^{\text{th}}$ item = 40 which lies in 53rd item, therefore median class is 20 – 30

Then apply following formulae

$$\text{Median} = L + \frac{\left(\frac{N}{2} - \text{cf}\right)}{f} \times i = 20 + \frac{\left(\frac{80}{2} - 30\right)}{23} \times 10 = 20 + 4.35 = 24.35$$

3rd Deciles or D_3 = value of $3N/10^{\text{th}}$ item = $3 \times 80/10^{\text{th}}$ item = 24 which lies in cf 30, therefore 3rd quartile class is 10 -20

Then apply following formulae

$$D_3 = L + \frac{\left(\frac{3N}{10} - \text{cf}\right)}{f} \times i = 10 + \frac{\left(\frac{3 \times 80}{10} - 16\right)}{14} \times 10 = 10 + 5.71 = 15.71$$

53rd Percentiles or P_{53} = value of $53N/100^{\text{th}}$ item = $53 \times 80/100 = 42.4^{\text{th}}$ item which lies in cf 53, therefore 53rd percentile class is 20 – 30. Then apply following formulae

$$P_{53} = L + \frac{\left(\frac{53N}{100} - \text{cf}\right)}{f} \times i = 20 + \frac{\left(\frac{53 \times 80}{100} - 30\right)}{23} \times 10 = 20 + 5.40 = 25.40$$

Relationship between Mean, Median and Mode

Mean, Median and Mode have their distinct role and they cannot be substituted for one another. Arithmetic mean is the most commonly used average. It is suitable when one wants give equal importance to the values of a series. It is based on all the observations, but unduly affected by the presence of extreme items. It helps to compare two different distributions relating to the same variable e.g., compare per capita income of India and China for the evaluation of level of economic development in two countries.

Median is suitable where the objective is to determine an average that would indicate its position among other values in the series. It helps to avoid the effect of the extreme items.

Mode is the best suitable to determine the most frequently occurring item in a series. It is generally used to describe the qualitative data.

Thus, it is important to select an appropriate average depending upon the purpose of analysis and the nature of the distribution.

Comparisons of Mean, Median and Mode

Basis for comparison	Mean	Median	Mode
Definition	Rigid	Rigid	Not Rigid
Calculation	Easy	Easy	Easy
Based on all observations	Yes	No	No
Capable of Mathematical treatment	Yes	No	No
Affected by extreme values	Yes	No	No
Computed graphically	No	Yes	Yes

Assessment Activity

Which average would be suitable in the following cases?

- Average wages in an industrial unit
- Average size of Shoes for adults
- Average intelligence of students in a class
- Average production in a factory per shift

TE Questions

- The most suitable average for qualitative measurement is
 - arithmetic mean
 - median
 - mode
 - above all
- Which average is affected most by the presence of extreme values ?
 - mode
 - median
 - Arithmetic mean
 - none of the above
- The sum of deviations of items from the arithmetic mean is always
 - +1
 - 1
 - 0
 - none of the above
- complete the series
 - Quartile — The value which divide a series into four equal parts
 - Deciles —

5. If the arithmetic mean of the data given below is 28. Find the missing item

21, 25, 26, 30, 24, 27, 31, ?, 29, 34

6. Match the following

Average — The sum of the values of all items divided by number of items

Mode — Divide the series into 100 equal parts

Percentile — Value which occurs most frequently

Median — Single value that represents whole data

Mean — Positional Average

7. What is meant by Measure of central tendency?

8. How can we determine Mode when the value of Mean and Median are given?

9. Compute mean, median and mode from the following data

Income	70 - 80	80 - 90	90 - 100	100 - 110	110 - 120	120 - 130	130 - 140
No. of families	150	140	115	95	70	60	40

Extended Activity

Collect the data with help of a schedule from 10 families in your locality and find average income, expenditure and savings of each family.

Unit VII

Measures of Dispersion

- 7.1. Meaning and Significance of Measures of Dispersion.
- 7.2. Properties of a good measure of Dispersion.
- 7.3. Methods of studying Dispersion.
- 7.4. Absolute and Relative Measures of Dispersion.
- 7.5. Range - Individual Observation, Discrete Series, Continuous Series.
- 7.6. Coefficient of Range.
- 7.7. Quartile Deviation - Individual Observation, Discrete Series, Continuous Series.
- 7.8. Co efficient of Quartile Deviation
- 7.9. Mean Deviation - Individual Observation, Discrete Series, Continuous Series.
- 7.10. Co efficient of Mean Deviation
- 7.11. Standard Deviation - Individual Observation, Discrete Series, Continuous Series.
- 7.12. Co efficient of Standard Deviation/Variance

Introduction

Averages are the representatives of a given data. However the individual values in the series may vary too much from the average. In such case, we cannot say that the average calculated is truly representing the whole series. It necessitates the study of variations to know the reliability of the average. The averages of two series may be same but reliability may be different. This chapter enables students to measure the variation of values from average, compare the averages of two or more series of data and identify the most consistent series.

Learning Outcomes

The learner;

- *Identifies the Meaning and Significance of Measures of Dispersion.*
- *Lists out various Methods of studying Dispersion.*
- *Recognises the use of Absolute and Relative Measures of Dispersion.*
- *Calculates Range*
- *Interprets the result by using Coefficient of Range.*
- *Calculates Quartile Deviation*
- *Identifies the use of Quartile Deviation*
- *Interprets the result by using Co efficient of Quartile Deviation*
- *Calculates Mean Deviation*

- *Interprets the result by using Co efficient of Mean Deviation*
- *Identifies the limitations of range, quartile deviation and mean deviation.*
- *Identifies the concept Standard Deviation.*
- *Solves problems of Standard Deviation.*
- *Recognizes the use of Standard Deviation*
- *Interprets the result by using Co efficient of Standard Deviation*
- *Lists out the Qualities of a good measure of Dispersion.*

Meaning and Significance of Measures of Dispersion

Marks secured by six students from three commerce batches are given:

Batch	Marks				
A	51	52	50	48	49
B	30	35	50	65	70
C	0	15	45	95	95

Observe the data given above;

What is the average mark? Does similar average mean similar nature of data? What about the variation in marks among students of batch A and C?

Average condenses information into a single value. However, average alone is not sufficient to describe the distribution completely. To ensure the reliability and consistency of the average, we have to see how each individual values are scattered (varied) from the average value. An average has little significance unless the degree of variation in the distribution is known. Dispersion measures the degree of variation in a distribution. If variation is small, an average becomes meaningful and useful, and if the variation is large the average has only limited significance. Therefore, an average is meaningful, when viewed with the help of dispersion.

Assessment Activity

Marks secured by students from three commerce batches of a VHSE school along with the average marks.

Batch	Marks					A. M
A	51	52	50	48	49	50
B	30	35	50	65	70	50
C	0	15	45	95	95	50

Examine the table and observe the variations of marks in each batch from the average.

Properties of a good measure of dispersion

- Easy to calculate and simple to understand
- Rigidly defined: For the same data, all the methods should produce the same result.
- Based on all the items so as to be more representative.
- Amenable to further algebraic treatment.
- Sampling stability.
- Not unduly affected by the extreme items.

Methods of studying dispersion

- ❖ Range
- ❖ Quartile Deviation
- ❖ Mean Deviation and
- ❖ Standard Deviation

Absolute and Relative Measures of dispersion

When the dispersion is measured and expressed in terms of the original data, it is called an absolute dispersion. For example, average weight of 10 people is 50 kg with a deviation of .5 kg. Here the dispersion is expressed in the unit in which the data are expressed, in our example it is 'kg'. Absolute measures of dispersion cannot be used for comparison purposes if expressed in different units.

In order to make the comparison of the dispersion of two more distributions meaningful, they should be brought to some common base. For this, the absolute measure of dispersion has to be expressed as a ratio or percentage of the average, which called relative measure ie, co-efficient of dispersion.

Assessment Activity

Examine the following data and Find the average of each data. Write down the difference between each value of the data and the average. Discuss the possibility of differences you have seen into a single measure. Also see whether comparison possible between these data if one data is in cms and one data is in kgs. Is it useful to get a single value which facilitates comparison also?

<i>Height (in cms):</i>	150	165	170	180	160
<i>Weight (in kgs):</i>	50	60	65	75	70

Range - Individual Observation, Discrete Series, Continuous Series

Range is the difference between the highest and the lowest value in a series. It is simple to calculate and easy to understand but it is not based on all the observations. It is suitable for a small group with less variation.

$$\text{Range} = L - S$$

Assessment Activity

Study the following data;

- The market price of share, Kitex recorded at regular interval on a particular day.

456 458 475 472 468 486 467

- Temperature recorded for a day at Munnar in April 2016.

11 14 12 10 8 11 9

- The price of Orange charged in 100 shops in a district;

Price	No. of Shops
45	6
50	54
55	35
60	5

- The monthly salary paid to 1000 employees in a factory.

Salary	No. of employees
5000 - 10000	180
10000 - 15000	220
15000 - 20000	300
20000 - 25000	160
25000 - 30000	140

Write down the lowest and highest value in each data and record the difference.

7.6. Coefficient of Range

$$\text{Coefficient of Range} = \frac{L - S}{L + S}$$

Assessment Activity

Study the following data;

- The market price of share, Kitex recorded at regular interval on a particular day

458 475 472 468 486 467

The market price of share, Hindalco recorded at regular interval on a particular day

78 67 75 63 80 74

2. Temperature recorded for a day at Munnar in April 2016

11 12 9 8 10 9

- Temperature recorded for a day at Palghat in April 2016

40 39 38 41 37 36

3. The price of Orange charged in 100 shops in Kannur district;

Price	No. of Shops
45	6
47	54
50	35
52	5

- The price of Orange charged in 100 shops in Pathanamthitta district;

Price	No. of Shops
50	6
52	54
54	35
57	5

4. The monthly salary paid to 1000 employees in a Cashew factory.

Salary	No. of employees
5000 - 10000	180
10000 - 15000	220
15000 - 20000	300
20000 - 25000	160
25000 - 30000	140

- The monthly salary paid to 1000 employees in a Coir factory.

Salary	No. of employees
2000 - 4000	180
4000 - 6000	220
6000 - 8000	300
8000 - 10000	160
10000 - 12000	140

Write down the lowest and highest value in each data and record the difference.

Calculate co-efficient of range

Comment on the answers.

Quartile Deviation - Individual Observation, Discrete Series, Continuous Series

The Range uses only two extreme items. Hence, any change in the in-between observations is not going to affect the range. This is the main drawback of range. Moreover, in many situations, extreme items are widely separated from remaining items. In this situation, range will overestimate the dispersion. Thus range fails to give true picture of dispersion. In order to overcome these drawbacks, range of middle 50% items are computed. The middle 50% items lie in between the two quartiles, Q1 and Q3. So it is also called Inter Quartile Range.

$$\text{Quartile Deviation (QD)} = \frac{Q_3 - Q_1}{2}$$

Co efficient of Quartile Deviation

$$\text{Co efficient of Quartile Deviation} = \frac{Q_3 - Q_1}{Q_3 + Q_1}$$

Assessment Activity

- Observe the following data;
3 34 45 54 32 38 93
Write down the smallest and largest value.
Find range and Coefficient of range.
What demerit you notice in the answer.
- Arrange the following data in ascending order
3 34 45 54 32 38 93
Find Q1
Find Q3
Find Co efficient of Quartile Deviation

Notice the difference between answers of Activity 1 and Activity 2

What made the difference?

- Calculate Quartile Deviation and its co efficient from the following data;

Price	Quantity Purchased
50	163
100	116
150	78
200	62
250	49
300	31

4. Calculate Quartile Deviation and its co efficient from the following data;

Number of Workers	No of Factories
0 - 50	78
50 - 100	96
100 - 150	94
150 - 200	92
200 - 250	79
250 - 300	61

One of the requisites of a good average is that it should be based on all the observations. However QD depends upon only two partition values.

Mean Deviation - Individual Observation, Discrete Series, Continuous Series

In this method, deviations of items from mean, ignoring positive and negative signs, is averaged to get the absolute measure.

Its co efficient is calculated by dividing the Mean Deviation by the Mean.

$$\text{Mean Deviation (MD)} = \frac{\sum |D|}{N}$$

$$\text{For Discrete and continuous series, Mean Deviation (MD)} = \frac{\sum f|D|}{N}$$

Co efficient of Mean Deviation

$$\text{Co efficient of Mean Deviation} = \frac{MD}{Mean}$$

Assessment Activity

1. The following are the number of units produced by a worker in a factory for 7 days.

54 37 45 52 45 56 47

Calculate the Arithmetic Mean.

Find difference between each value and the Arithmetic Mean.

Sum the differences.

Divide the sum of difference by the number of values.

Find the co efficient by applying the formula

2. Calculate Mean Deviation and its co efficient from the following data by the following the steps; calculate mean, find out the difference between mean and the values,

multiply the difference with the frequency, take the sum of the product and apply the formulae.

Number of Children	Number of Families
0	3
1	4
2	6
3	4
4	3

3. Calculate Mean Deviation and its coefficient from the following data;

Daily Wage	No of Workers
0 - 100	2
100 - 200	3
200 - 300	4
300 - 400	3
400 - 500	2

The disadvantages of Mean Deviation are;

- it is not helpful in further analysis because further mathematical treatment is limited.
- It ignores the plus and minus signs.

Standard Deviation - Individual Observation, Discrete Series, and Continuous Series

Standard deviation (SD) is the most commonly used measure of dispersion. It is a measure of spread of data about the mean. SD is the square root of arithmetic mean of squared deviations taken from the arithmetic mean of a series. It is denoted by σ (read as sigma, a lower case Greek letter).

For Individual Observation $S.D. (\sigma) = \sqrt{\frac{\sum d^2}{N}}$

Illustrative Example

Compute S.D. for the following data;

36 15 25 10 14

Solution

$$\sum X = 36+15+25+10+14 = 100$$

$$\text{Arithmetic Mean} = \frac{\sum X}{N} = \frac{100}{5} = 25$$

						Total
X	36	15	25	10	14	100
d (X – AM)	11	-10	0	-15	-11	-11
d ²	121	100	0	225	121	567
†	$= \frac{\sqrt{567}}{5} = \sqrt{113.4} = 10.65$					

$$\text{For Discrete and Continuous Series S.D. (†) } = \frac{\sqrt{\sum fd^2}}{N}$$

SD is used as a measure of dispersion when mean is used as measure of central tendency (ie, for symmetric numerical data).

The reason why SD is a very useful measure of dispersion is that, if the observations are from a normal distribution, then;

68% of observations lie between mean \pm 1 SD

95% of observations lie between mean \pm 2 SD and

99.7% of observations lie between mean \pm 3 SD

The other advantage of SD is that along with mean it can be used to detect skewness.

The disadvantage of SD is that it is an inappropriate measure of dispersion for skewed data. For skewed numerical data, median and interquartile range are used.

SD by Deviation Method

Step 1: Decide assumed mean (a)

Step 2: Compute deviation (d) from assumed mean (a) $d = X - a$

For discrete and continuous series multiply d with frequency i.e. fd

Step 3: Square the deviations (d²)

For discrete and continuous series multiply d² with frequency i.e. fd²

Step 4: Find the sum of 'd' ie, $\sum d$ or $\sum fd$

Step 5: Find the sum of 'd²' i.e. $\sum d^2$ or $\sum fd^2$

Step 6: Apply the formulae and find SD.

$$\text{S.D. (†) } = \sqrt{\frac{\sum d^2}{N} - \left(\frac{\sum d}{N}\right)^2} \quad (\text{for individual series})$$

$$\text{S.D. } (\dagger) = \sqrt{\frac{\sum fd^2}{N} - \left(\frac{\sum fd}{N}\right)^2} \quad (\text{for discrete and continuous series})$$

SD by Step Deviation Method

Step 1: Decide assumed mean (a)

Step 2: Compute deviation (d) from assumed mean (a) $d = X - a$

Step 3: Divide d by a common factor 'c' i.e. $d' = \frac{d}{c}$

For discrete and continuous series multiply d' with frequency i.e. fd'

Step 4: Square the deviations (d'^2)

For discrete and continuous series multiply d'^2 with frequency i.e. fd'^2

Step 5: Find the sum of 'd' i.e. $\sum d'$ or $\sum fd'$

Step 6: Find the sum of 'd²' i.e. $\sum d'^2$ or $\sum fd'^2$

Step 7: Apply the formulae and find SD.

$$\text{S.D. } (\dagger) = \sqrt{\frac{\sum d'^2}{N} - \left(\frac{\sum d'}{N}\right)^2} \times c \quad (\text{for individual series})$$

$$\text{S.D. } (\dagger) = \sqrt{\frac{\sum fd'^2}{N} - \left(\frac{\sum fd'}{N}\right)^2} \times c \quad (\text{for discrete and continuous series})$$

Co efficient of Standard Deviation

$$\text{C.V.} = \frac{\text{S.D.}}{\text{A.M.}} \times 100$$

Variance and Standard Deviation

Variance is the average of the squared differences from the mean. Variance measures how far a set of numbers are spread out. Standard Deviation is the square root of the variance.

$$\begin{aligned} \text{Variance} &= \dagger^2 \\ \dagger &= \sqrt{\text{variance}} \end{aligned}$$

Assessment Activity

- Compare the procedures under Deviation Method and Step Deviation Method and find the difference.
- Calculate C.V.

$$\text{A.M.} = 25$$

$$\text{S.D.} = 10.65$$

- Compute S.D. and C.V. of marks scored by 10 candidates given below;
54 61 64 69 58 56 49 57 55 50
- The following are the share prices of two companies, Adani Ports and Asian Paints for the last 7 days. Calculate standard deviation and its co efficient and comment which company's share is more consistent.

Ambuja Cement 235 217 258 277 218 238 285

Asian Paints 1381 1414 1515 1400 1350 1425 1325

- Calculate the standard deviation and co efficient of variation for the frequency distribution of marks of 100 candidates given below;

Marks 0-20 20-40 40-60 60-80 80-100

Why square the differences?

If we just added up the differences from the mean ... the negatives would cancel the positives:

$$4 + 4 - 4 - 4 = 0$$

So that won't work. How about we use absolute values?

$$|4| + |4| + |-4| + |-4| = 4 + 4 + 4 + 4 = 16$$

That looks good (and is the Mean Deviation), but what about this case:

$$|7| + |1| + |-6| + |-2| = 7 + 1 + 6 + 2 = 16$$

Oh No! It also gives a value of 4, Even though the differences are more spread out! So let us try squaring each difference (and taking the square root at the end):

$$\sqrt{4^2 + 4^2 + 4^2 + 4^2} = \sqrt{64} = 8$$

$$\sqrt{7^2 + 1^2 + 6^2 + 2^2} = \sqrt{90} = 4.74\dots$$

That is nice! The Standard Deviation is bigger when the differences are more spread out ... just what we want!

And it is easier to use algebra on squares and square roots than absolute values, which makes the standard deviation easy to use in other areas of mathematics.

(Source: www.mathsisfun.com)

Merits of S.D

- Based on all observations
- Capable for further mathematical treatment
- It does not ignore algebraic signs
- It is not much affected by sampling fluctuations

TE Questions

1. Which one of the following is a relative measure of dispersion?
a. Range b. Inter-quartile Range c. Co-efficient of Range d. Standard Deviation.
2. If mean is 25 and Standard Deviation is 5, then Co efficient of Variation is;
100 % b 25% c. 20 % d. non of these
3. If Variance is 64, what is Standard Deviation?
a. 4096 b. 8 c. 128 d. 32
4. Which of the following is a wrong statement?
a. Range is the difference between the highest and lowest value.
b. Range is an absolute measure of dispersion.
c. Range is a suitable measure for further algebraic treatment.
d. Range is suitable for small groups with less variation.
5. The squared deviations of the mean divided by the number of observation is called;
a. Variance b. Standard Deviation
c. Co-efficient of Standard Deviation d. either a or b.
6. What is the significance of measuring dispersion?
7. What are the properties of a good measure of dispersion?
8. What is the draw back of absolute measure of dispersion?
9. Why is relative measure of dispersion used?
10. Which are the different methods of measuring dispersion?
11. When is a range used?
12. What is the formula for co efficient of range?
13. What is the demerit of range?
14. What do you mean by inter quartile range? Why is it so called?
15. Why is quartile deviation used?

16. What is the limitation of quartile deviation?
17. What is the formula for mean deviation?
18. Which are the steps for the calculation of mean deviation?
19. What is the formula for standard deviation?
20. What is the advantage of standard deviation over mean deviation?
21. What is the best measure of deviation? Why?
22. Calculate Range and its co efficient for the following data;

3	1	5	4	6	2
---	---	---	---	---	---
23. Calculate Inter Quartile Range and its co efficient for the following data;

4	3	5	8	3	6	7	6	8	1
---	---	---	---	---	---	---	---	---	---
24. Calculate Mean Deviation and its co efficient for the following data;
 3, 6, 6, 7, 8, 11, 15, 16
25. Calculate Standard Deviation and its co efficient for the following data;

Foot Size	1-3	3-5	5-7	7-9
Number of Students	40	30	20	10
26. By using the measure of Standard Deviation and its co efficient, find out which of the following share show more consistent performance?

South Indian Bank	20	20	26	19	18	24	22
Federal Bank	58	65	78	90	55	45	54

Extended Activity

Collect marks obtained by all students in your class in first year VHSE examination and analyse the data with the help of dispersion measures and comment on its findings.

Unit VIII

Correlation

- 8.1. Meaning of Correlation
- 8.2. Types of Correlation
 - Simple, Partial and Multiple
 - Positive and Negative
 - Perfect and Imperfect
 - Linear and Non linear
- 8.3. Methods of studying correlation
 - Scatter Diagram method
 - Pearson's Co-efficient of Correlation
- 8.3.3. Spearman's Rank Correlation

Introduction

Measures of Central tendency and Dispersion are dealt with a single variable. In many cases, there exists some sort of relationship among variables and is required to measure the degree and extent of such relationship numerically. Correlation is a tool in statistics which is used to measure the relationship among the variables. Correlation analysis helps in several decision making areas of management. For example, price of a product and its competitive products, amount spend on advertisement and sales generated, training programme given to workers and their efficiency, etc. This unit gives an idea about the concepts of correlation, types of correlation and techniques of measuring correlation.

Learning Outcomes

The learner;

- *Identifies the nature of relationship between variables.*
- *Recognises the concept of correlation*
- *Distinguishes different types of Correlation*
- *Recognises the idea of drawing scatter diagram*
- *Identifies the type of correlation from a scatter diagram*
- *Classifies the types of correlation*
- *Recognises the concepts of correlation coefficient*
- *Identifies properties of correlation coefficient*

- *Distinguishes direct and short cut methods*
- *Computes correlation coefficient under two methods*
- *Recognises the concepts of rank correlation*
- *Identifies the circumstances in which rank correlation is preferred*
- *Distinguishes different situations for calculating rank correlation coefficient*
- *Computes rank correlation coefficient under three situations*

Meaning of Correlation

Consider the following variables;

height, weight, intelligence

Which among them is related/ not related ? Do height and weight move in the same direction/ opposite direction? What is the degree of relationship?

In practical context, very often, we have to study the relationship between two or more variables.

For example, between rainfall and agricultural production, income and expenditure of a family, number of workers and time taken to complete a job, training given and performance of employees, price of product and its demand etc.

The term 'correlation' means relationship between two or more variables. The two or more variables are said to be correlated if changes in one variable induces in changes in other variables. As a statistical tool, correlation helps to measure the degree and direction of relationship between variable quantitatively in a single value called 'correlation coefficient'. The value of correlation co-efficient will always be between +1 and -1. Correlation studies and measures the direction and intensity of relationship among variables. Correlation measures covariation, not causation (cause and effect relationship).

Types of correlation

Correlation may be classified into the following categories.

1. Simple, Multiple and Partial correlation

Depending upon the number of variable to be correlated, correlation is classified into simple, multiple and partial on the basis of number of variables correlated in a study.

The relationship between two variables are called simple correlation.

Hence the study considers only two variables. Eg. Income and savings of an individual.

If one variable is related to a number of other variables the correlation is said to be multiple. Eg. relationship between the demand of a product and other demand determinants.

If one variable is related to a number of other variables and we study only the relationship between that variable and any one of the other variables the correlation is said to be partial. For example, in a study of demand of a products and demand determinants, we study only the relationship between demand and price by keeping other variables constant.

2. Positive and Negative correlation

On the basis of direction, correlation may be positive or negative.

If changes (increase or decrease) in one variable leads to changes in another variable in the same direction, the correlation is said to be positive. Eg: price of a product and its supply.

The correlation is negative when the variables move in opposite direction.

Eg. Awareness campaign and use of tobacco products.

3. Perfect and Imperfect correlation

On the basis of rate of change in the variables, correlation may be perfect or imperfect.

If changes in one variable result in changes in another variable at the same rate on either direction (increase or decrease) the correlation is said to be perfect.

Eg: one variable 'x' increases or decreases by 10 point. Then the other variable 'y' increases or decreases by 10 point.

If changes in one variable results in changes in another variables at different rates on either directions the correlation is said to be imperfect.

Eg: one variable 'x' decreases by 10 points, then the other variable 'y' increases or decreases by 15 Or 20 points but not 10 points.

4. Linear and Non Linear correlation

On the basis of shape of the data when plotted on a graph correlation may be linear and non linear. If the points corresponding to the ordered pairs formed, by taking the corresponding values of the correlated variables cluster around a line, then the correlation between the two variable is said to be linear. If the point clusters around a curve, then the correlation between two variables is said to be non linear or curvi - linear.

Methods of measuring correlation

1. Diagrammatic Method
2. Mathematical Method

1. Diagrammatic Method

Diagrammatic Method is also called scatter diagram method. It is one of the simplest methods to study the simple correlation. Hence we need to plot the pair values of two variables on a graph paper by taking the first variable on 'X' axis and second

variable on 'Y' axis. The scattering of the points on the paper will give you a diagram and the pattern of scattering tells you the nature of relationship exists there.

- Eg: (a) If the points are concentrated on a line from lower left to upper right there exists a Perfect positive correlation.
- b) When the points are concentrated on a line from upper left to lower right, there exists a perfect negative correlation.
- (c) If the points plotted moves from lower left to upper right not on a single line, there exists positive correlation
- (d) If the points plotted moves from upper left to lower right not in on a single line, there exists negative correlation.
- (e) If the points plotted widely scattered over the diagram there exists no correlation

Assessment Activity

The price of shares of a company on BSE and NSE in 10 different days randomly collected over a period of last three years are given below. Draw a scatter diagram and comment on the nature of correlation.

Days	1	2	3	4	5	6	7	8	9	10
BSE	65	90	52	44	95	36	48	63	80	15
NSE	62	71	58	58	64	40	42	66	67	55

2. Mathematical method:

- (a) Karl Pearson's Method
- (b) Rank Correlation

Karl Pearson's Coefficient of Correlation (Pearsonian coefficient of correlation)

Pearsonian coefficient of correlation is the most widely used method of measuring simple correlation. It gives a precise numerical value of the degree of linear relationship between two variables X and Y and is denoted by 'r'. The value of 'r' always is between +1 and -1. The value of 'r' can be interpreted as follows;

$r = 1$: Perfect positive correlation

$r =$ between 1 and 0 : Imperfect positive correlation

$r = 0$ - No correlation

$r =$ between 0 and -1 : Imperfect negative correlation

$r = -1$: Perfect negative correlation

Karl Pearson's co-efficient of correlation can be calculated by using

- (a) Direct Method (deviations from Actual Mean)
- (b) Short –cut method (deviations from Assumed Mean)

(a) Direct Method (Deviations from Actual Mean)

Under this method, co-efficient of correlation between any two variables is measured on the basis of the deviations of the items obtained from their respective actual arithmetic mean.

$$\text{Under this method, } r = \frac{\sum xy}{\sqrt{\sum x^2 \sum y^2}}$$

Steps

1. Find out the arithmetic average of both the variable
2. Take the deviation of X series from the mean of X and denote the deviation by x
3. Square these deviations and obtain the total i.e., $\sum x^2$
4. Take the deviations of Y series from the mean of the series and denote these by y.
5. Square these deviations and obtain the total i.e., $\sum y^2$
6. Multiply the deviations of X and Y series and obtain the total, ie, $\sum xy$
7. Substitute the values of $\sum xy$, $\sum x^2$, $\sum y^2$ in the above formula.

Assessment Activity

1. Calculate Karl Pearson's coefficient Correlation from the following data

X	12	9	8	10	11	13	7
Y	14	8	6	9	11	12	3

(Hint: + 0.95)

2. Calculate the co-efficient of correlation between birth rate and death rate from the data given below

Year	Birth rate	Death rate
1931	24	15
1941	26	20
1951	32	22
1961	33	24
1971	35	27
1981	30	24

b. Short-cut Method (Deviations from Assumed Mean)

Under this method deviations from Assumed mean are taken for the computation of correlation coefficient.

$$r = \frac{\sum dxdy - \frac{(\sum dx)(\sum dy)}{N}}{\sqrt{\sum dx^2 - \frac{(\sum dx)^2}{N}} \sqrt{\sum dy^2 - \frac{(\sum dy)^2}{N}}}$$

Steps

1. $dx = (X - A)$; A is the assumed mean of X series
2. $dy = (Y - A)$; A is the assumed mean of Y series
3. $\sum dx$ = sum of the deviations of X series from the assumed mean
4. $\sum dy$ = sum of the deviations of Y series from the assumed mean
5. $\sum dxdy$ = sum of the product of the deviations of X and Y series from their assumed means
6. $\sum dx^2$ = sum of the squares of deviations of X series from the assumed mean
7. $\sum dy^2$ = sum of the squares of deviations of y series from the assumed mean
8. N = Number of pairs of observation

Example

Calculate Karl Pearson's co-efficient correlation between the values of X and Y given below;

X	78	89	96	69	59	79	68	61
Y	125	137	156	112	107	136	123	108

Solution

A = 69			A = 137			
X	dx (X - 69)	dx ²	Y	dy (Y - 137)	dy ²	dx dy
78	+ 9	81	125	- 12	144	- 108
89	+20	400	137	0	0	0
97	+28	784	156	+19	361	532
69	0	0	112	- 25	625	0
59	-10	100	107	- 30	900	300
79	+10	100	136	- 1	1	- 10
68	- 1	1	123	- 14	196	+14
61	- 8	64	108	- 29	841	+232

$$N = 8 \quad \sum dx = +48 \quad \sum dx^2 = 1530 \quad \sum dy = -92 \quad \sum dy^2 = 3068 \quad \sum dxdy = 960$$

$$r = \frac{\sum dxdy - \frac{(\sum dx)(\sum dy)}{N}}{\sqrt{\sum dx^2 - \frac{(\sum dx)^2}{N}} \sqrt{\sum dy^2 - \frac{(\sum dy)^2}{N}}} = 0.95$$

There is high degree of positive correlation between X and Y

Assessment Activity

Calculate the coefficient of correlation that exist between price and quantity and comment on it.

Price	Quantity
10	5
10	6
11	4
12	3
12	3

Rank Correlation

Rank correlation method was developed by the British psychologist C. E. Spearman. It is used when the variables cannot be measured in quantitative terms as in case of intelligence, leadership quality, degree of honest, sense of cooperation etc. In such cases we can only rank individuals or objects according to their quality of variables.

Under Spearman's Rank correlation method, co-efficient is based on the ranking of the various values of the two variables. These ranks are used for the calculation of correlation. This coefficient provides a measure of linear association between ranks assigned to these variables, not their values.

The Steps for calculation of Rank Correlation

1. Determine the ranks of X (R_1) and Y (R_2)
2. Take deviations of the ranks of X (R_1) from the Ranks of Y (R_2) and denote these as D
3. Square the deviations and add them to obtain $\sum D^2$
4. Apply formula $= 1 - \frac{6\sum D^2}{N(N^2 - 1)}$

The value of Rank correlation coefficient is interpreted in the same way that of Karl Pearson's correlation coefficient, hence its ranges between +1 and - 1. The calculation of rank correlation will be illustrated under three situations

1. The ranks are given.

2. The ranks are not given. They have to be worked out from the actual values.
3. Ranks are repeated

1. When the ranks are given

Example

Five persons are assessed by two judges in a beauty contest and ranks of them are given below. Calculate Spearman's rank correlation and comment on it

Judge	<i>a</i>	<i>b</i>	<i>c</i>	<i>d</i>	<i>f</i>
A	2	4	1	5	3
B	1	3	5	2	4

Solution:

A (R_1)	B (R_2)	D ($R_1 - R_2$)	D^2
2	1	1	1
4	3	1	1
1	5	-4	16
5	2	3	9
3	4	-1	1
Total			28

$$R = 1 - \frac{6 \sum D^2}{N(N^2 - 1)} = 1 - \frac{6 \times 28}{5(5^2 - 1)} = 1 - 1.4 = -0.4.$$

Thus perceptions of judge A and B have very different tastes.

2. When the ranks are not given

When no ranks are given, we must assign ranks. Ranks can be assigned by taking the highest as 1 and rank others accordingly.

Example

The marks secured by 5 students in Management and Accountancy are given below. Calculate the rank correlation coefficient.

Marks in Management	85	60	55	65	75
Marks in Accountancy	60	48	49	50	55

Solution:

Marks in Mgt.	Marks in Acc.	Ranks in Mgt. (R_1)	Ranks in Acc. (R_2)	D	D^2
85	60	1	1	0	0
60	48	4	5	-1	1
55	49	5	4	+1	1
65	50	3	3	0	0
75	55	2	2	0	0

$$\sum D^2 = 2$$

$$R = 1 - \frac{6 \sum D^2}{N(N^2 - 1)} = 1 - \frac{6 \times 2}{5(5^2 - 1)} = 1 - 0.1 = 0.9$$

3. When the ranks are repeated

When two or more items have equal values, we should rank them progressively and give each item an average rank, e.g., if the two values are ranked equal at fifth place, they are each given a rank $5 + 6 / 2 = 5.5$. The formula of Rank correlation coefficient when the ranks are repeated is as follows;

$$R = 1 - \frac{6 \left(\sum D^2 + \frac{1}{12}(m_1^3 - m_1) + \frac{1}{12}(m_2^3 - m_2) + \dots \right)}{N(N^2 - 1)}$$

where m_1, m_2, \dots are the number of repetitions of ranks in X and Y.

Example

The Values of X and Y are given below. Compute Coefficient of correlation.

X	25	45	35	40	15	19	35	42
Y	55	80	30	35	40	42	36	48

Solution:

X	Y	R_1	R_2	D	D^2
25	55	6	2	4	16
45	80	1	1	0	0
35	30	4.5	8	-3.5	12.25
40	35	3	7	-4	16
15	40	8	5	3	9
19	42	7	4	3	9
35	36	4.5	6	-1.5	2.25
42	48	2	3	-1	1

$$R = 1 - \frac{6 \left(65.5 + \frac{1}{12}(2^3 - 2) \right)}{8(8^2 - 1)} = 1 - \frac{6(65.5 + 0.5)}{504} = 1 - \frac{396}{504} = .214$$

Thus there is positive rank correlation between X and Y, i.e both X and Y move in the same direction.

Assessment Activity

Identify the circumstances in which rank correlation coefficient is preferred to simple correlation coefficient? Discuss

TE Questions

- The range of simple correlation coefficient is
 - 0 to infinity
 - minus one to plus one
 - minus infinity to infinity
 - 0 to plus one
- If sum of the product of deviations of X and Y series from their means is zero, the coefficient of correlation shall be
 - +1
 - 0
 - 1
 - None of these
- List some variables where accurate measurement is difficult.
- Positive correlation - Variables are varying in the same direction
 - Negative correlation -
 - Linear correlation -
- Calculate the correlation coefficient between the heights of fathers (X) and their sons (Y)

X(in inches)	:	65	66	57	67	68	69	70	72
Y(in inches)	:	67	56	65	68	72	72	69	71

Extended activities

- Collect the market price of a share of SBT during the last 10 days and compare the same with SENSEX average of those days using correlation and interpret the result.
- Select 10 families of your locality and collect their income and expenditure during last month and make a correlation analysis.

Unit IX

Index Number

- 9.1. Meaning
- 9.2. Types of Index Numbers
 - Price Index
 - Quantity Index
 - Cost of Living Index
 - Whole Sale Price Index
- 9.3. Uses and Purpose
- 9.4. Methods of constructing Index Numbers
 - Simple Index Number
 - Weighted Index Number
 - Laspeyres' Method
 - Paasche's Method

Introduction

When you read Daily News Papers or watch T V News, you might have noticed that the SENSEX Index was dropped down by 200 points or shoot up by 300 points and so. What does it indicate? It is the ratio of the average change in today's market price of group of securities/shares in relation to their prices at particular previous date.

Learning Outcomes

The learner;

- *Explains the meaning and characteristics of index number*
- *Classifies and describes various types of index numbers*
- *Describes the uses and purpose of index numbers*
- *Illustrates the various methods of construction of index numbers*

Meaning of Index Numbers

Index numbers are specialised averages designed to measure the changes in variables or group of variables either over a period of time or at various places. Variables maybe prices of specified list of commodities, volume of products in different sectors of an industry, production of various agricultural crops etc. For example, the aggregate market price of shares of 50 companies is Rs.4500/- as on 29/3/2016, the aggregate market price

of those on 28/3/2016 is Rs.4000/-The index number of those shares on 29/3/2016 to the base 28/3/2016 $= (4500 \div 4000) \times 100 = 112.5$ points. It reveals that share price index is increased by 12.5%, in a single day. If the index points exceeds 100 points, It means there is an increase in the market price of shares. If it falls below 100 points, it means the decrease in the market price of the shares.

In short , it is a statistical device for measuring relative changes in the magnitude of variables from one point of time to another.

Definition

According to Spiegel , “An index number is a specialised measure designed to show changes in a variable or a group of related variables with respect to time, geographical location or other characteristics”

Features

1. Index numbers are specialised averages used to compare only those services which are expressed in same units
2. It measures the net changes in a group of related variables
3. It measure the effect of changes in variables or related variables over a period of time

Assessment Activity

Wages of a carpenter during the year 2006 was Rs. 300/- per day and he spent Rs. 60/- daily for food requirements . During the year 2016, he need Rs. 120/- per day for food requirements.

1. How much wages should be given to him in the year 2016 to maintain his purchasing power capacity as that of 2006 based on food expenditure?
2. Can you calculate it ?

Uses of index numbers

Index numbers are mainly used for the following purposes.

1. Index number helps the Government to formulate the suitable policies in the field of Economics, Business, Social services, etc.
2. It discloses the trends and tendencies of a group of variables or related variables over a period of time. ie, days/years/months, etc.
3. It is used to determine the rate of Dearness Allowance payable to employees from different sectors from time to time.
4. It helps to measure the purchasing power of money.

Assessment Activity

Index numbers are used in many areas of business like Fixation of Minimum wages of employees in different sectors. List out other practical applications of index numbers in business.

Types of Index numbers

Following are the important types of Index numbers

1. Price Index
2. Quantity Index
3. Cost of living Index
4. Whole sale price Index

Price Index

Price index numbers measures and permits comparison of the prices of certain goods. It is more widely used. It represents the changes by a single numerical measure.

It shows the price index of particular variable or variables.

It can be calculated by using the following formula-

$$P_{01} = \left(\frac{\sum P_1}{\sum P_0} \right) \times 100$$

P_{01} = Index number for the current year

P_1 = Current year price of a commodity

P_0 = Base year price of a commodity

$\sum P_1$ = Sum of the prices of group of related commodities in current year

$\sum P_0$ = sum of the prices group of related commodities in base year

Quantity Index Number

The index numbers which are based on quantities of commodities as well as volume of services rendered are called quantity index numbers. Quantity index numbers measures the changes in the physical volume of production, construction or employment.

Cost of living Index Number (Consumer price Index Number)

Cost of living index number is also known as the consumer price index (CPI), measures the average changes in retail prices. Cost of Living index numbers are intended to represent the average change over a period of time in the prices paid by ultimate consumer for a specified quantity of goods and services. The need to calculate it arises because the general index number fails to provide clear idea about the effect of changes to the general prices level on the cost of living of different classes of people.

For example: CPI for industrial workers is increasingly considered the appropriate indicator of general inflation, which shows the most accurate impact of price rise on the cost of living of common people.

Significance of Cost of living Index number

1. It helps to determine the purchasing power of money
2. It helps to determining the real wage
3. It helps the employers for wage negotiation and fixing the rate of Dearness Allowance

Whole sale price index

The wholesale price index number indicates the changes in the general price level. Unlike the CPI, it does not have any reference consumer category.

What does the statement “WPI” with 1993-94 as base is 189.1 in march, 2005” mean? It means that the general price level has risen by 89.1 percent during this period

It reveals the prices changes for all commodities sold at a particular place or in a particular year with reference to a base year. It is used as a good indicator of general economic changes. The whole sale price trend of commodities in a country is reflected through this index numbers. It is one of the widely used index numbers.

Assessment Activity

From the following Index number identify its type.

1. Index number which takes into account prices of the variables only.
2. Index numbers of variables are commuted by taking into account of both the prices as well as quantity of each variables.
3. Index number takes into account relative importance of each variables in connection with the commodities used by different people in different locations.
4. Index number indicates the general economic changes

Methods of construction of Index Number

There are various methods for constructing Index Numbers. They may be broadly grouped under two heads-

- A) Simple Index Number
- B) Weighted Index Number

Simple Index Number

It may be again sub-divided under two heads-

- 1) Simple aggregate price method (aggregate method)
- 2) Simple average price relative method

Simple aggregate price method

It is the simplest method for the construction of Index number. The formula for the computation of simple aggregate price index is,

$$P_{01} = \left(\frac{\sum P_1}{\sum P_0} \right) \times 100$$

$\sum P_1$ = aggregate current price for all commodities.

$\sum P_0$ = aggregate of base year price of all commodities

Assessment Activity

From the data given below construct the aggregate price index number for the year 2015 on the base of 2005

Commodity	Price in 2005	Price in 2015
A	20	40
B	50	60
C	40	50
D	20	30

Simple Average price relative Method

Under this method price relative of each item is calculated ie, (current year price/Base year price) x 100. Then these are averaged to get the index number.

The formula is;

$$P_{01} = \frac{\sum \left(\frac{P_1}{P_0} \times 100 \right)}{N}$$

P_{01} = Index number for the current year

P_1 = current year price of the commodity

P_0 = base year price of the commodity

N = Number of items of commodities averaged

Assessment Activity

From the data given below construct an index number for 2015 taking 2005 as a base by the average relatives method

Commodities	Price in 2005	Price in 2015
A	500	750
B	450	700
C	900	1050
D	1200	1500
E	250	300

Weighted Index Number

An Index number becomes a weighted index when the items are given weights according to their relative importance. Depending upon the methods, Price relatives, Base year price, Base year quantity, Current year price and Current quantity are used for the computation weighted index number.

The following are two popular methods under weighted aggregative method to calculate weighted index number;

- 1) Laspeyer's price index method
- 2) Paasche's price index method

Laspeyer's price index method

Under this method base period quantities are used as weight. Formula for the calculation of Index Number under this method is,

$$P_{01} = \frac{\sum P_1 q_0}{\sum P_0 q_0} \times 100$$

P01 = Index number for the current year

P1 = Current year price of the commodity,

q0 = Base year quantity of the commodity

P0 = Base year price of the commodity

Paasche's Price index method

It uses the current period quantities as weights. A weighted aggregative price index using current period quantities as weights is known as Paasche's price Index method.

The formula for the calculation price Index under this method is-

$$P_{01} = \frac{\sum P_1 q_1}{\sum P_0 q_1} \times 100$$

P01 = Index for the current year

P1 = Current price of the commodity,

q1 = Current year quantity of the commodity

P0 = Base year price of the commodity,

q0 = Base year quantity of the commodity.

Assessment Activity

Construct index numbers of prices from the following data by applying Laspeyers' method and paasche's method

Commodities	Prices in 2005	Prices in 2015	Quantity in 2005	Quantity in 2015
A	200	450	8	12
B	500	950	12	13
C	400	800	10	8
D	200	450	4	3

TE Questions

Choose the correct answer from the following

- An index number which accounts for the relative importance for the items is known as
(a) Weighted Index number (b) simple aggregate index number
(c) simple average relative index number
- A consumer price index measures changes in-
(a) Retail price (b) Wholesale price (c) producers price
- Adjusting original data into real values in the case of index number is
(a) Inflating (b) deflating (c) averaging (d) none of these
- The item having the highest weight in consumer price index for industrial worker is
(a) food (b) Housing (c) clothing (d) others
- In general, inflation is calculated by using-
(a) Wholesale price index (b) consumer price index (c) producers' index

Find the odd one and give reason

- (a) Retail price Index (b) Price of living index (c) Index of industrial production (d) cost of living index
- (a) Laspeyer's Index number (b) Paasche's index (c) weighted index (d) simple aggregate price index

Short Questions

- Index numbers are described as "barometers of economic activity". Explain.
- Consumer price indices are of great importance because of various reasons. What are they?

10. What do you mean by Wholesale Price Index number?
11. What is meant by Cost of Living Index number?
12. What are the uses of Index numbers?
13. Explain the features of Index numbers.
14. Explain the meaning and significance of Consumer Price Index Numbers.
15. Construct an index number for the year 2011 taking 2010 as base.

commodities	Price in 2010	Price in 2011
A	100	110
B	70	85
C	110	120
D	50	55

16. Compute a price index for the following by average of price relative method by using Arithmetic mean.

Commodities	Price in 2005	Price in 2006
A	40	50
B	60	60
C	20	30
D	50	70
E	80	90
F	100	110

17. Calculate index number from the following data by applying Laspeyres' method and paasche's method.

Items	Base year quantity (kg)	Base year price (rate)	Current year quantity (kg)	Current year price (rate)
Rice	10	30	8	40
Meat	20	350	15	450
Tea	2	125	3	150

Extended activities

1. Collect prices of selected food items in one year back and in the current year. Prepare index number by giving quantity consumed during current year as weight.
2. Find out the method adopted by Government of India for the compilation of cost of living index in India

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