SECTION – I

THEORIES AND LAWS OF ECONOMICS

Chapter 1

Introduction to Engineering Economics

Chapter synopsis: *Engineers are planners, manufacturers and builders. In the beginning of the 20^{th} century, engineers were mainly concerned with the design, construction, operation of machines structures and processes. But today, as managers, they are the decision makers and problem solvers to achieve optimal results. While this book details most of the principles and applications of economic methodologies for engineers in making the above cited decisions, more aptly called 'Engineering Economics', this chapter introduces the subject and distinguishes and traces it how it metamorphosised from the theoretical economics, as was popular during the ancient days.*

Keywords: *Macro-economics, micro-economics, economic theories, theoretical economics, syllabi of engineering economics, cost benefit analysis, SWOT, HEATCO, cost oblivious approach, cost benefit approach, combination of professional and personal ethics.*

1.1 Engineering Economics

Among several professions like medicine, law etc., engineering is that profession which requires creativity and judgment to develop new processes and products that would increase the standard of living of the public. The former American President, Herbert Hoover, an engineer himself, has described engineering profession as under

> *It is a great profession. There is the fascination of watching a figment of imagination emerge through the aid of science to a plain paper, and then it moves to a realization in stone or metal or energy. Then it brings jobs and homes to men. Then it elevates the standards of living and adds to the comfort of life. This is the engineer's high privilege*

In other words, engineering has become the profession in which the knowledge gained in mathematics, statistics and natural sciences and most all economics, is applied to the technical knowledge with judgment to develop methods to utilise, the manpower, materials, machinery and other resources in the most economical manner. Engineering Economics helps us to understand the need for the knowledge of Economics to analyse the data available and take suitable decisions. As highlighted in the preface, this chapter emphasizes the significance of engineering economics to the engineers and later distinguishes it from the theoretical economics.

When several alternatives to achieve a definite purpose are available, engineering economics analyses, estimates, and evaluates the economic results seeking solutions to problems, and the economic viability of each potential solution giving due consideration to all the technical aspects.

1.2 Macro-Economics and Micro-Economics

Economics, which we may call here as pure economics or economic theory, to distinguish from engineering economics, is the academic study of the theories dealing with the principles of demand, pricing, cost, production, competition, trade cycles, national income and so on, as discussed in detail in the later chapters.

Economics in general, has two major branches, macro-economics and micro-economics. Macro-economics is the study of the economy as a whole especially of a nation's wealth, economic situation, money policy etc., and may also include the impact of an individual person's or a firm's demand, supply and consumption behaviour on the nation's aggregate demand, aggregate supply, national income, investment etc. On the other hand, micro economics is the study of the individualistic behaviour of the firm or a house hold, like factors of production, demand and supply situation distribution economics etc., which have direct or indirect impact on micro economics as explained above. The term micro comes from Greek expression for closer look, whereas macro appears to be a hybrid term.

To this effect, we may consider engineering economics as micro-economics related to the manufacturing activity and studies the behaviour of individuals and firms in making decisions regarding the allocation of limited resources. For example, for deciding between two alternatives for a project or a major activity, like capital purchase or potential investment, we have to compare the costs against the benefits of each alternative, and in engineering economics this is called cost benefit analysis. Several software aided by Operations research and other mathematical techniques are now increasingly used to assess and analyse the economic evaluation of alternatives.

1.3 Engineering Economics vs. Theoretical Economics

Earlier, the engineering students were taught economics as a humanity subject, that is the basics of the macroeconomics and economic theories and laws, without much emphasis on technical applications of economics like cost benefit analysis, make or buy decisions and replace/repair analysis for machinery. This made the engineering Students show less interest in this subject. There were several cases, where brilliant engineering students, who score high marks in technical subjects either fail or get moderated in economics. For this reason, several Western universities, and later by most Indian universities amended their syllabi to suit engineering managerial decisions. It may be noted that few Indian universities are yet to amend, as evidenced by their syllabi given in the appendix.

In short, the differences between macroeconomics and engineering economics can be summarised as below.

Table 1.1 *Theoretical Economics vs Engineering Economics*

No.	Aspect	Macro or Theoretical Economics	Engineering Economics
1.	Emphasis	Macroeconomics, national oriented	Microeconomics, industry oriented
2.	Illustrations	Trade and Commerce oriented	Manufacturing industry oriented
3.	Laws	Laws of Economics	Industrial applications of Laws of Economics
4.	Supply and demand	Elasticity of demand and supply, and laws of supply and demand, which effect the national production as a whole	Demand forecast to assist strategic planning, aggregate planning, capacity planning etc
5.	Laws of substitution	Selection of goods to produce	Make or buy decision
6.	Consumption	Propensity to consume	Voice of the customer to decide on the products and the quality features.

1.4 History of Engineering Economies

Arthur M. Wellington, who was involved in the design and construction of new railways in Mexico was the first to address during the 1870's, the role of economics in decision making in engineering projects. Eugene L. Grant. was the first to publish a book on the *Principles of Engineering Economy* in 1930.

1.5 Elements of Engineering Economies

The 5 Major elements of engineering economies, which are discussed further in latter chapters are

1. Cost benefit analysis, being the chief aspect of engineering economics is discussed in the subsequent paragraphs of this chapter.
2. Time value of money - whereas pure economics focuses on the value of money, engineering economics focuses on the time value of money, and estimation of cash flows, as discussed in chapter 6.

3. Quantitative measurements of profitability and systematic comparison of alternatives as listed below and illustrated and discussed in subsequent chapters,
    - Interest and Money - Time Relationships
    - Depreciation and Valuation
    - Capital Budgeting
    - Risk, Uncertainty, and Sensitivity Analysis
    - Fixed, Incremental, and Sunk Costs
    - Value Analysis
    - Material Layout planning
    - Plant Location
    - Replacement Studies
    - Minimum Cost Formulas
    - Various Economic Studies in relation to both Public and Private Ventures

1.6 Cost Benefit Analysis

Cost benefit analysis (CBA), is a systematic approach to estimate the strengths, weaknesses, opportunities and threats (SWOT) of alternatives. It presumes that a monetary value, say rupee value, can be assigned to all the costs and benefits of an action or a project, including tangible and intangible returns like the environmental effects to the stakeholders, other companies and most of all, to those effected persons and sums them up to compare the overall benefits against the costs involved.

1.7 Standard Operation Procedure for Cost Benefit Analysis

1. Define the goals and objectives of the cost benefit project you are undertaking.
2. Make a list of all possible alternative choices possible.
3. Make a list of all possible benefits and costs associated, in separate columns, for each alternative, preferably by brainstorming. The costs shall include all direct and indirect costs, intangible costs, opportunity costs, and most importantly, the costs of potential risks. Benefits shall include all direct and indirect revenues and other intangible benefits, like the increased production from improved employee safety and morale, or increased sales from customer goodwill.

4. Where possible, assign a rupee value to each cost and benefit. Make sure not to underestimate or overestimate costs and benefits. Involving other related persons in brainstorming is the ideal process.
5. Now analyse and compare the results of the aggregate costs and benefits quantitatively to determine if the benefits outweigh the costs.
6. Make a recording of these followed by a report to the management.

1.8 History of the Cost Benefit Analysis

- Jules Dupuit, a French engineer and economist is credited with the creation of cost–benefit analysis in 1848.
- The Federal Navigation Act of USA in1936, and the Flood Control Act of 1939 mandated cost benefit analysis for the waterway infrastructure.
- UK adapted this for the MI Motorway project as well as the Underground tube railway.
- In Europe**,** Harmonised European Approaches for Transport Costing and Project Assessment' (HEATCO) was started in 2010 for European transport policy.

1.9 Limitations of Cost Benefit Analysis

1. Over-reliance on data from past projects
2. subjective impressions in assessment
3. Inappropriate use of heuristics to derive rupee value for the intangible costs
4. Mind set and bias among project supporters.

1.10 Basic Approaches for Application of Cost Benefit Analysis for Resolving Environmental Problems

1.10.1 Cost Oblivious Approach

All efforts made to make the environment as clean as possible, whatever, may be the cost to do so.

- ♦ No level of environmental degradation is accepted.
- ♦ This approach is somewhat similar to that of *rights and duty ethics*, as described in the books of professional ethics.
- ♦ Though ideal, this approach has two obvious problems.
    - It is difficult to define exactly what is *as clean as possible* and

- In the highly competitive world of Indian industry, where every rupee counts, industries try to use the above vagueness as a loophole and only try to do minimal expenditure to provide short run measures enough to create an impression among the public that they are protecting the environment which may not be true in the long run.

1.10.2 Cost Benefit Approach

The problems are analysed in terms of the benefits derived by reducing the pollution problems. The costs and the benefits are weighed as described in paragraph 1.7, determine the optimum combination.

- Here the target is not to achieve a completely clean environment but an economically viable environment protection.
- This can also be compared to *Utilitarian theory* of professional ethics.

However, this approach too suffers from 4 major difficulties.

- It is difficult to assess the true cost of human life or loss a species or environmental protection.
- It is difficult to assess accurately the costs and benefits, and much guess work or factor of safety has to go into the calculations.
- This approach does not necessarily specify who should bear the cost and who should get the benefit.
- The cost benefit analysis does not take morality and ethics into account. The decision is simply based on mathematical simulations and calculations and there is no room for a discussion whether what is done is right or wrong.

1.10.3 A Combination of Professional and Personal Ethics

Unlike professional decisions like bridge designs, projects involving environment affects the engineer too, himself being a member of the public. Hence the need to apply his decision making with reference to his personal ethics.

Whatever may be the approach it is essential that the engineer applies both his professional and personal ethics, at the same time meticulously following the laws and regulations of the state.

From the perspective of human health, the engineer's responsibility to protect is clear, which must be balanced between the consideration of the well-being of his employer, the public and the community.

1.11 Conclusion

Paragraph 1.10 above provides an illustration of the cost benefit analysis for the decision making that will affect the environmental issues. Without ignoring engineering economics as the finance department's job, it is essential for the engineers to understand clearly the technical aspects of economics, especially the cost benefit analysis, to enable them to take several managerial decisions in their day to day career. This chapter hence introduces these aspects, which are further discussed in detail in subsequent chapters.

Further Reading

1. *Cost-Benefit Analysis for Development: A Practical Guide*, by Asian Development Bank
2. Kiran D. R. *Professional Ethics and Human Values*, McGraw Hill Education, 2009
3. Boardman, N. E. (2006). *Cost-benefit Analysis: Concepts and Practice* (3rd ed.). Upper Saddle River, NJ:
4. Kiran, D. R., Production Planning & Control, a Comprehensive Approach, BS Publishers, 2018,
5. Kiran, D. R., Work Organisation and Methods Engineering, BS Publishers, 2019,
6. Dunn, William N. (2009). *Public Policy Analysis: An Introduction*. New York: Longman. Prentice Hall
7. Kiran, D. R., *Lecure notes for Grad. IIE Examinations* NIMT, 1986
8. Gerald J. Thuesen et al, Engineering Economy - A Historical Perspective, Georgia Institute of Technology.
9. https://www.betterevaluation.org/en/evaluation-options/CostBenefitAnalysis

Criteria Questions

1. 'Engineering is a great profession' Elaborate (1.1)
2. Distinguish between Macro-Economics and Micro-Economics (1,2)
3. Relate engineering -economics with macroeconomics (1.3)
4. What do you understand by Cost Benefit Analysis? Discuss. (1,7)
5. Discuss the Approaches for Application of Cost Benefit Analysis. (1.10)