Industrial Engineering Journal
ISSN: 0970-2555
Volume : 53, Issue 2, No. 4, February : 2024

MATHEMATICAL CONCEPTS IN MODELING DEMAND AND SUPPLY CHAIN IN ECONOMICS

Shobha T, Professor Dept. of Mathematics, Seshadripuram First Grade College, Yelahanka Newtown, Bengaluru, India e-mail: shobhabt@yahoo.com
Ramesh T C Professor Dept. of Mathematics, Seshadripuram First Grade College, Yelahanka Newtown, Bengaluru, India e-mail: rameshtc1971@gmail.com

Abstract:
Mathematical models play a crucial role across various fields and disciplines, aiding in the derivation of precise outcomes through systematic calculations. Within economics, the theories of demand and supply serve as fundamental pillars, requiring rigorous mathematical grounding for strategic decision-making. By employing mathematical concepts, tools, and models, decision-makers can effectively analyze and interpret data to make informed choices regarding demand and supply dynamics. This study endeavors to establish a correlation between mathematical models and decision-making processes, illustrating how these models can be utilized to derive insights and inform decisions about demand and supply.

Keywords:
Mathematics, Tools, Techniques, Optimization.

I. Introduction

The integration of mathematics into economics traces back to the early 19th century, initially termed classical economics. Initially, economic concepts were expressed using algebra, with calculus not yet incorporated. In 1936, economist Wassily Leontief pioneered Input-Output analysis by utilizing 'material balance' tables developed by Soviet economists. Mathematical optimization, within mathematics, involves selecting optimal elements from a given set. In economics, optimization extends to finding the best element of a function within a specified domain, employing various computational techniques. Economics is intricately tied to the optimization behavior of economic agents, with a prominent definition characterizing it as the study of human behavior concerning ends and scarce means with alternative uses, forming the basis for economic theorems subject to empirical testing. Mathematics serves as a tool in economics to articulate the relationship between testable propositions and complex subjects through mathematical modeling. Presently, much economic theory is articulated through mathematical models.

II. Objectives of the study

1. Understanding economic theory and concepts using mathematics.
2. To solve economic problems using mathematical tools.

III. Methodology

The study is based on secondary data. The author refers to articles books, journals and research articles etc.

Mathematical concepts used to explain economic theory

1. **Functions:** Function is a relation between two variables, we denote it by y =f(x), where ‘x’ is called independent variable and ‘y’ is called dependent variable. For every value of ‘x’ there corresponds one or more value of ‘y’.

Example: Q = Q (p), where Q is Quantity and P is Price. These are the basic building blocks of economic models. The function D= D (p) is a demand function and its graph with price on one axis

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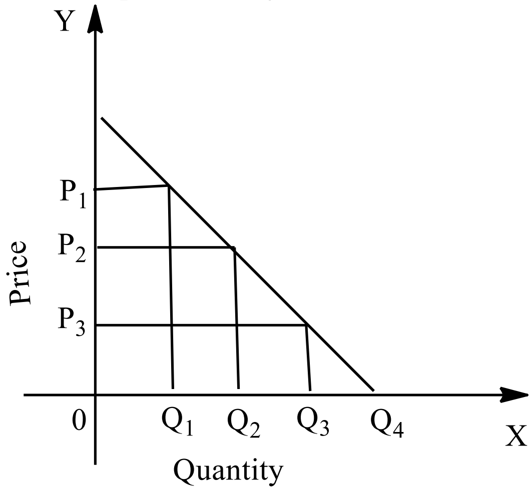
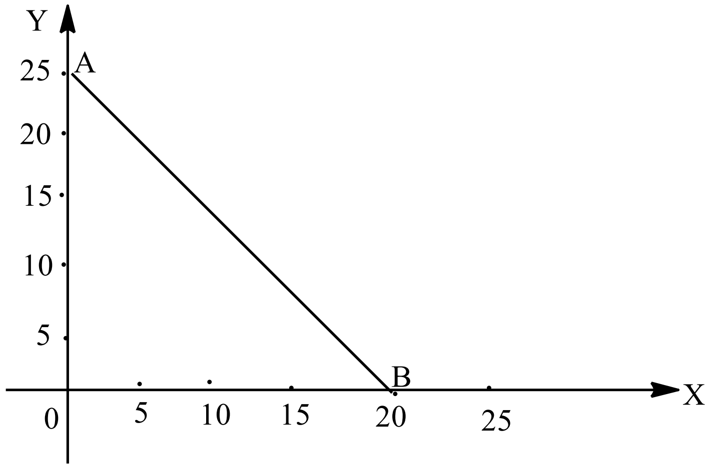
and quantity on the other axis will give a demand curve. It indicates the cause-effect relationship between variables. A function can be represented by means of a table or graph.



Deviation of demand curve from law of diminishing marginal utility.

2. Algebra: A set is a collection of well defined objects. In economics, the need is to define an opportunity set of decision maker. i.e., the set of alternative actions which are feasible. For example, the opportunity set of a consumer is the set of all combinations of goods which the consumer can buy with his given income. Given the consumer's budget and prices of all goods, the opportunity set is well defined and we can find out whether the consumer can buy that combination of goods. If a person consumes only two goods (x, y) , whose prices are Rs. 5 and Rs 4 unit and his income is Rs 100, the opportunity set is as shown below.



If the consumer spends all his income on 'x', he can buy 20 units of 'x' with no y(B) or if he spends all on the goods 'y' then he buys 25 units of 'y' and no x(A). All other alternatives of spending Rs 100 will lie on the line AB. Hence, the area OAB constitutes the consumer's opportunity set.

Algebra also includes addition, subtractions multiplication and division etc., we require these in solving economic equations such as in Bain's concept of entry,

$$E = \frac{P_L - P_C}{P_C}$$

E = Condition of entry

P_L = Limit of price

Pc = Price under pure competition in the long-run

In calculating present value, suppose that RS Q are invested for one year at the rate of interest 'i' percent compound annually, then at the end of the year we would get Rs iQ as interest which, with the return of principle 'Q', would give us Q + iQ = Q (1 + i) rupees. If the initial sum is designated as Q_0 and the sum at the end of one year as Q, then we get the expression,

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$Q_1 = Q_0 (1+i)$

3. **Variables:** Variables are things which change and can take a set of possible values within a given problem. A constant or parameter is a quantity which does not change in a given problem.
For example y=a + bx. Here 'a' and 'b' are constants and 'x' and 'y' are variables. 'x' is the independent or exogenous variable while 'y' is the dependent or endogenous variable. The values of 'x' will be given from outside the system, while the values of 'y' will be determined from within the system. 'x' can assume different values and this will cause y to assume different values also.

4. **Differentiation:** It is the measure of the rate of change of one variable concerning other variables. In economics decisions are based on mathematical concepts 'Derivatives'. This process is called "marginal analysis".
Example: The marginal product of a factor of production is defined as a change in output due to a tiny change in the quantity of this factor while quantities of all other factors of production remain constant Then,

$$MP_L = \Delta_X / \Delta_L \text{ and } MPx = \Delta_X / \Delta_K$$

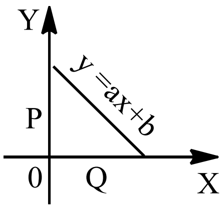
Where, MP_L = Magnetic product of Laboure and MPk =Marginal product of capital.
Mathematically, the marginal product of a factor of production is the partial derivative of the production function concerning this factor.

$$MP_L = \delta_X / \delta_L \text{ and } MPx = \delta_X / \delta_K$$

5. **Slope:** The concept of slope is important in economics because it is used to measure the rate at which changes are taking place. The unit of change in X (independent variable) will result in a change in 'y' (dependent variable).

Slope =(change in y)/(change in x)

In economics, slope is used to measure how things will change. For example, how the demand changes when prices change or how the consumption changes when income changes.
If the slope of a line y = a x + b is positive then the line moves upward when going from left to right. Similarly, when the slope is negative the line moves down when going from left to right. The following graph shows a downward sloping demand curve which declines as price increases.



6. **Partial derivatives:** In business economics we encounter a function of several independent variables.
Example: demand of a product on the part of the consumer depends on the price of the product. The prices of other related goods, consumer's income, consumer's wealth, consumer's tastes, and so on. When the price of the goods changes, the effect on the quantity demanded of the goods can only be analyzed if all other variables are held constant, the functional relationship that we get between the quantities demanded of a product and its price is called a partial function. The process of differentiation can be applied to the partial function is known as the partial derivatives of the original function and is denoted by $\delta f/\delta x$.
Example: The quantity of goods sold in a firm depends on the price of the product(p), the income of the consumer (y), and the amount of money spent on advertising(a) This can be written as q=f(p,y, a). If the firm needs to know the effect of advertising on the number of goods sold, then we have to treat

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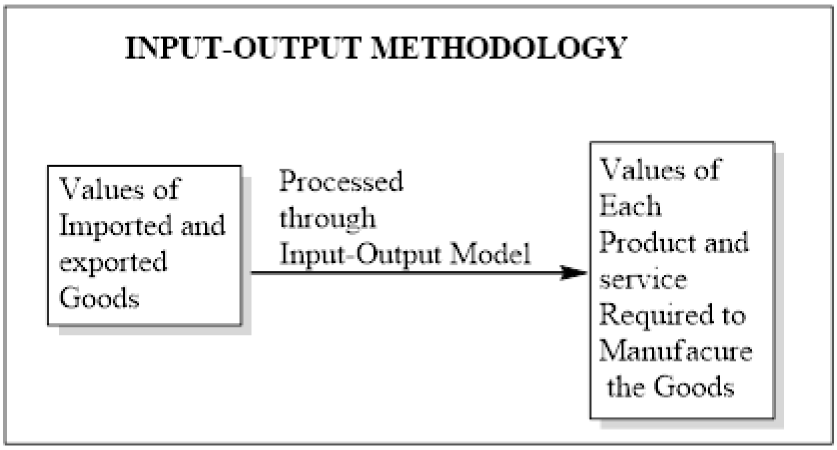
the price and income of consumers as constant and advertising as variable. This can be achieved by taking partial derivatives of the function concerning advertising ie.,δq/δa.

7. **Maxima:** The maxima of a function are the highest value that is reached over a closed interval.
Example: The equilibrium of the project maximizing firm occurs simultaneously on the input and output sides. i.e., a firm that is maximizing its profit by choosing an output at which marginal cost equals marginal revenue. i.e., simultaneously minimizing the cost of producing the output or maximizing the output subject to cost constraint.
For maximum, the first derivative is equal to zero and the second derivative is < 0.
For minimization, the first derivative is equal to zero and the second derivative is > 0.

8. **Input-output analysis:** Input-output is a very popular economic analysis though it is not an optimized one. Matrix is basic for understanding the rationale and use of input-output models such as model essentially states the nature of technological relationship, which exists between sectors. By using this model, we can stipulate a change in the exogenous variables and use the model to determine the system of equations using technological relationships to determine the changes to be made to sustain the new level of autonomous variables.



9. **Linear programming:** Linear programming is defined as a method of determining an optimum programme of interdependent activities given available resources to maximize or minimize an objective function. A mathematical might be more technical and may define linear objective function subject to certain linear constraints.
Any linear programming problem has three constituents,
9.1 Objective function: An objective function of the linear programming problem must be clearly defined mathematically.
9.2 Constraints: The decision variables of the linear programming problem are interrelated and the resources are taken to be limited in supply. These constraints are expressed in the form of inequalities which describe the problem in linear form.
9.3 Non-negativity constraints:
This emphasizes that the units of commodities produced or consumed are either zero or more than zero.
There are many methods to solve linear programming problems, to mention a few as below
(i) Simple method
(ii) Simplex method
(iii) Northwest corner method
(iv) Least cost method

10. **Statistical tools and Techniques:** A decision maker gathers information in the form of statistical figures for the demand for the product, production levels, inputs used, market shares, advertisement, expenditures and their input on sales, price behavior over a period, and so on. The information collected has to be tabulated in the form of statistical tables called frequency distribution and then it has to be analyzed by working out various 'Constraints' to make inferences using various Probability Distributions, Correlation, Regression, Analysis of variance, and Test of significance, etc.,

IV. Conclusion

The language of mathematics allows economic problems and concepts to make specific, positive claims about controversial or contentious subjects that would be impossible without mathematics. From the above study, it can be concluded that students who are looking to pursue a career in economics are advised to strengthen their knowledge in mathematics and statistics. To analyze problems in economics they need mathematical concepts like calculus, matrix algebra, linear programming, etc., are vital.

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