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Co-relation between mathematics and economics: A study of various mathematical tools

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Abstract
Every education stream whether science, humanities, commerce has its own way of reasoning and thinking. Sciences are mainly based on experimental verification of various types of research carried out whereas humanities are based on observation only. Two important subjects that exist in humanities and sciences are Mathematics and Economics and this paper deals with their co-existence. The field that defines their co-existence is Mathematical Economics which is becoming quite important for any person studying economics. Mathematical economics is a science which helps us in converting various economic theories into compact form by applying various mathematical techniques. The paper deals in explanation of various mathematical and statistical tools that are widely used in the field of economics for obtaining simple models of various complex economic problems. The advantages and disadvantages of using maths in economics is also dealt with.

Keywords: mathematics, economics, interdependence, tools

Introduction

Mathematical Economics is define as the technique of using various mathematical tools for studying, analysing various complex economic problems and to modify them into simple problems which are easy to understand and comprehend. The use of maths in economics can be accounted by the two following reasons

1. Economic Fundamentals, articles and prepositions can be easily understood with the help of mathematics.
2. The application of maths helps in making the subject look a bit easier.
3. The application of maths helps to develop logical thinking for understanding of the subject as the subject maths itself is based on logics thus helping in wide spread improvement of inductive , rational and logical thinking of the individual .

Economics is one of the pillars of various subjects of social sciences which deal with studying of the economic activities of a country as a whole. It studies the various effects of changes that are caused due to nature or by mankind on the society or country as a whole. e.g

1. The effect of drought or floods in increase or decrease of crop production and thus leading in fluctuation of prices.
2. The effect of MNREGA in improving economic conditions of rural India

These observations form the basis of various economic policies to be framed by the various state and central governments taking a cue from past and thinking about future. For all these to be done mathematics plays a pivotal role. The application of maths helps in developing a scientific model for a given economic theory which is more practical, definite and provides an explicit relationship between various economic variables and laws. Sometimes it is not possible to comprehend a topic using existing knowledge of the subject. In such situations maths plays an important role in developing a concrete and deductive model for it to be adopted unanimously and provides working knowledge for the topic.
Although both of these subjects are independent in nature and have their own existence. We will try to enunciate there interdependence. The various mathematical functions and statistics tools that can be used for making the subject easy to understand and also the relation between the two subjects. We will try to explain how sound knowledge of maths can help in in better and good understanding of Economics. Though maths has various applications in economics in one and other way but we will try to explain some important applications of maths in economics and how it is co related to theit.

Applications of Mathematics in Economics

1. Function

A function is defined as a rule, a method, a map, a correspondence which establishes a relationship between elements of two sets. A function describes the connection between two or more than two variables. That is, a function expresses dependence of one variable on one or more variables. Thus mathematically if the value of variable y depends upon the the value of a variable x then it can be represented as

$$y=f(x) \quad \text{(i)}$$

The above rule shows that for a unique x there exist a a value characterized by y .The function defined in (i) represents that value of y is dependent on the value of x. The variable y is called the dependent variable and the variable x is called the independent variable. The application of functions in

economics can be understood by considering the concept of demand and supply .Demand is a function of supply and supply is a function of production which in turns is dependent on various others factors . The whole can be expressed as

$$D=f(S) \quad \text{(ii)}$$

Where D represents demand and S represents Supply. Similarly the functional relationship between supply and production can be expressed as

$$S=g(P) \quad \text{(iii)}$$

Where S denotes Supply and P represents Production.

Continuing in the same sense Utility, Cost, Revenue, Profit, Supply, Savings etc., are the functions of some more dependent and related variables. The utility of a commodity (U) depends on the quantity of the commodity consumed which can be functionally expressed

$$U=(Q) \quad \text{(iv)}$$

If the variable Y depends on more than two variables say X_1, X_2….. , Xn then the function can be expressed

$$Y=f(X_1, X_2,.....,X_n) \quad \text{(v)}$$

2. 2) **Straight Line**

An expression of the form ax+by+c = 0 is a general equation of a straight line which represents a linear relationship between two variables. This depicts the increase and decrease in a variable if there is an increase and decrease in other variable. In the equation a, b can be any unknown real numbers whose values are generally to be determined. The straight line has a wide use in economics specially while depicting relation between two variables.

This function is commonly used in economic analysis, especially in demand and supply analysis. Consider the demand curve under perfect competition is a straight line, which can be expressed as 'Linear Equation' The demand can also write as

$$D=f(P) \quad \text{(vi)}$$

Which can be linearly expressed as D= 7-P. Here D is called the dependent variable and P is called the independent variable. The relation shows that demand is a linear function of production. This method is deemed fit where economic benefits from an asset are expected to be realized evenly over its useful life. Straight line method is also convenient to use where no reliable or accurate estimate can be made regarding the pattern of economic benefits expected to be derived over an asset's useful life.

3. Quadratic Functions

Quadratic Functions are generally second degree expressions defined as $y= ax^2 +bx + c$ which are generally called quadratic equations and usually represents parabolic curves. In physics they depicts projectile motion and graphically it represents an parabola which have different representations .Quadratic functions are used in economics as cost "functions" since, cost curves in economics are U shaped. Quadratic functions are often used in economics to represent both cost function and the revenue function. Suppose that the cost J, in rupees of producing x mobile phones is given by

$$J(x) = 56 +58x + 0.4x^2 \quad \text{(vii)}$$

The equation (vii) helps in evaluating cost for x number of objects sold and establishes a parabolic relationship between production and cost. Similar function can be define for revenue explaining how much a company can earn on producing x units after calculating all expenditures.

4. Euler theorem for Partial Differentiation

A function Z = f(x/y) is called homogeneous if $z= x^n f(x/y)$. Euler theorm plays important role in solving problems in partial differentiation involving homogeneous functions. The theorem can be stated as

If Z = f(x, y) is a homogeneous function of degree 'n' then,

$$x.dz/dx+y.dz/dy = nZ \quad \text{(ix)}$$

For example if $U =x^2 + y^2 +z^2$ then x. du/dx+ y.du/dy+ z.du/dz = 2U This is known as "Euler's Theorem on homogeneous functions. This Euler's theorem can be applied to Marginal productivity theory of Distribution in Economics. If $z= f$ (L, K) is linearly homogeneous function, then

$$Z = L.dz/dl+ k. dz/dk \quad \text{(x)}$$

Thus Partial derivatives play a pivotal role in economics, especially for those functions which are functions of two variables and desired results regarding marginal analysis can be obtained from partial derivatives. The use of partial derivative in economics can also be understood using the concept of consumption function which is a function of two variables income and wealth. The partial derivative of consumption function with respect to income gives marginal propensity.

5. Maxima and Minima

Let f(x) be a real valued function defined on an interval I. Then, f(x) is said to have the maximum value in the interval I, if there exists a point c in I such that $f(x) \leq f(c)$ for all $x \in I$. The number f(c) is called the maxima or the maximum value of f(x) in the interval I and the point c is called a point of maxima off in the interval I. Similarly if $f(x) \geq f(c)$ for all $x \in$ I then c is called the point of maxima and f(c) is called the maximum value of f for all x in I.

Similarly if f is a function of two variables say z = f(x,y) then the function is said to achieve its maximum value at (a,b) if $f(x,y) \leq f(a,b)$ for all (x,y) in the domain of function. Similarly if the function $f(x,y) \geq f(a,b)$ for all (x,y) in the domain of function. Maxima and Minima plays an important role in studying the firm equilibrium and consumer equilibrium. Maxima and minima often called as optimization techniques helps in calculating maximum utility of consumer

which is maximum when utility is maximum. Similarly achievement of maximum profit through differentiation we are able to achieve the equilibrium of the firm.

6. Differential Equations

The theory of differential equations has become an essential tool of economic analysis particularly since computer has become commonly available. It would be difficult to comprehend the contemporary literature of economics if one does not understand basic concepts (such as bifurcations and chaos) and results of modem theory of differential equations. Difference and Differential equations are very helpful to study the "Macro Economic Theories" and the 'Theories of Economic Growth." Application of "Differential Equations' to economic theories are abundant. A few of them are Multiplier and Accelerator Interaction and Cob-web Model and trade cycle Likewise, the application of differential equations to economic analysis is also much. For instance, a differential equation expresses the rate of change of the current state as a function of the current state. A simple illustration of this type of dependence is change of in (GDP) over time. Consider state x of the GDP of the economy. The rate of change of the GDP is proportional to the current GDP x' (t) = g (x (t))

where t stands for time and x'(t) the derivative of the function x with respect to t. The growth rate of the GDP is x' (t)/x. If the growth rate g is given at any time t, the GDP at time t is given by solving the differential equation. This is a first order differential equation which can be solved by separation of variables . The solution involves exponential function which states that t the GDP decays (increases) exponentially in time when g is negative (positive)

7. Simultaneous Equations

The equilibrium price is that price at which the quantity demanded equals the quantity supplied. This analysis is carried out through the solution of a system of two Simultaneous Equations with two unknowns: namely price and quantity.

Example:

Demand function =9P+20

Supply function = 11P+ 14

9P-11p = 14-20

-2P = -6 P= 6/2 =3.

An economic model is a theoretical representation of economic conditions using set of variables and establishing functional relationship between them based on logical and deductive reasoning. The model is a simplified version of realistic situations so as to obtain desired hypotheses about prevailing economic conditions and behaviour which are under study and observation. The economic model is based on mathematical rules which are formulated in such a way so as to explain a complex process in a more simple and lucid way. Economic models generally consist of a set of mathematical equations that describe a theory of economic behaviour. The economic models can be broadly classified as

1. **Theoretical Models:** These models are designed to ascertain and verify theoretically aspects of various current conditions under various constraints defined in the model using various mathematical techniques. They help in providing qualitative answers to various questions posed by different economic behaviour.
2. **Empirical formula:** These are used to conceptualize qualitative results obtained using theoretical models into numeric values which can be used to obtain desired results. Empirical models are generally very good in predicting results but it too suffers from systematic forecasting error which is there because of incorrect equations formed on the basis of various parameters and can be avoided by carefully selecting and inspection of variables.

Economic models have various functions but two of the most important functions are

1. Simplification and abstraction of data from observed data
2. Selection of data on the basis of econometric study.

Other important applications of economic models are given below

- Prognosticate economic activity in a manner such that the results are logically related to assumptions and suppositions.
- To put forward an economic policy on the basis of which predictions for futuristic economic activities can be stated and modified.
- The models help in providing reasonable points, arguments and facts on the basis of which the economic policy put forward is logically explained at various levels whether is it at national level , or at the level of company or simply it can be at the basic level of a household where a person prepares a model of his budget and tries to take common household decisions on the basis of the model
- Planning and allocation, in the case of centrally planned economies, and on a smaller scale in logistics and management of businesses.
- In finance predictive models have been used since the 1980s for trading (investment, and speculation), for example emerging market bonds were often traded based on economic models predicting the growth of the developing nation issuing them. Since the 1990s many long-term risk management models have incorporated economic relationships between simulated variables in an attempt to detect high-exposure future scenarios (often through a Monte Carlo method).

Mathematical models are widely used in development of economic models Mathematical models like input–output model and linear programming models are widely used by various corporate companies to decide about their future course of action and to prepare various strategies to succeed in market by using the predictions of various models. Determinants and matrix Algebra of Mathematics are of immense use in such techniques.

Mathematics is indispensable to calculate "capital formation" and interest rates.thus, in all most all fields of economics, mathematics is useful.

8. Econometrics

Econometrics literally means economic measurement. It is a combination of mathematical economics, statistics, economic statistics and economic theory. Econometrics literally means

economical measurement though the grammatically correct term from Greek would be economometrics, the word has been shortened in English. Econometricians are concerned with the tasks of developing and applying quantitative or statistical methods to the study and elucidation of economics principles. Econometrics is derived from mathematical economics, statistics, statistical economics, and economics theory. Osker Lange defines econometrics as *"The science, which deals with the determination quantitative laws occurring in economic life*." Econometric can measure the statistical importance of the economic relation. The most important statistical method in econometrics is regression and co-relation analysis, Regression methods are important in econometrics because economists cannot perform experiments under control environment and observational data is biased and may contain experimental errors which can be solved using statistical techniques like regression and other statistical methods. Econometric analysis is divided into time series analysis and cross sectional analysis. Time series analysis examines variables over time, such as the effects of population growth on a nation's GDP. Cross sectional analysis examines the relationship between different variables at a point in time, for instance, the relationship between individual's income and food expenditures. When time series analysis and cross sectional analysis are conducted simultaneously on the same sample, it is called panel analysis. If the sample is different each time, it is called repeated cross section data. Multi-dimensional panel data analysis is conducted on data sets that have more than two dimensions. Econometric analysis may also be classified on the basis of the number of relationships modelled. Single equation methods model a single variable (the dependent variable) as a function of one or more explanatory variables. In many econometric contexts such single equation methods may not be able to recover estimates of causal relationships because either the dependent variable causes changes in one of the explanatory variables or because variables not included in the model cause both the dependent and at least one of the independent variables. Simultaneous equation methods have been developed as one means of addressing these problems. Many of these methods use variants of instrumental variables models to make estimates. Much larger econometric models are used in an attempt to explain or predict the behaviour of national economies. In recent times eonometrics, has emerged as an important tool in economics.

The empirical content and policy significance are the two important faces of this new approach. Mathematical economics plays an important role in translating the verbal economic theories into its mathematical form. Econometrics, on the other hand, provides the necessary tools in testing the so-obtained mathematical statements of the concerned theory. Thus it is a branch of knowledge that deals with the empirical measurement of the economic relationships listed out in economic theories. It is also used to test the reliability of the inverse demand law by using statistical tools. Once the reliability of the relationship is established the so-obtained relationship is used to forecast the likely changes in the quantity demanded for an expected price change on a future date. This is the practical utility of econometrics.

One must remember that before testing a theory for its reliability, it must be first translated into a suitable mathematical form. It is also true that the statistical tools are commonly used in econometrics. Thus the basic relationships, which are analysed in econometrics, are economic relationships expressed in mathematical form. Hence, for a good understanding of the subject "*econometrics*" one must be good enough in economic theory, in addition to mathematical and statistical tools. In other words, we would say that econometrics is a combination of economics, mathematics and statistics.

Conclusion

Mathematics, used correctly in economy, is a tool of thought; it is a way of quickly reaching the goal, without becoming mandatory to be itself a goal of economic science It is quite clear that without having a good understanding of the mathematical concepts it will be difficult to have good grasp on economics. This shows that economics and Mathematics co-exist and sound knowledge of Maths is required for developing interest in economics and helps in making the subject more lucid to understand.

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