Applications of Mathematics and Statistics in Economics: An Analytical Study

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ABSTRACT

Investigating the applications of mathematics and statistics in economics is the aim of this study. It will examine how these quantitative methods are applied to assess economic data and draw informed judgements. This study will also look at the benefits and drawbacks of applying mathematics and statistics to economics. Weintraub's research indicates that there is no set mathematical point of reference for economics. He explains how the concepts of rigour and consistency in mathematics have changed over time and how it has become clear that mathematics cannot be represented as a complete formal system. This facilitates the identification of methodological problems in applied economics, which emphasises quantitative language. Examining basic mathematical tools commonly used in economics research, such as econometrics, macroeconomics, and microeconomics, is the aim of this paper. Economic concepts are inadequate if they are not supported by mathematical applications. For a proper knowledge of every economics topic, mathematics must be applied. By using mathematical techniques to make economic concepts understandable, one may become more interested in the subject.

KEYWORDS: mathematical economics, statistics in economics, economic modelling, quantitative analysis, econometrics, probability, algebra, calculus, economic forecasting, data analysis

INTRODUCTION

A branch of economics called mathematical economics develops hypotheses and solves economic puzzles by applying mathematical concepts and methods. Because of mathematics, economists are able to conduct quantitative tests, and every academic field has its own standards for assessing the validity of study results. Using mathematics in economics serves two functions: first, it equips you with the mathematical knowledge needed to create and understand economic arguments; second, it makes you more comfortable using mathematical terminology while discussing economics. Using mathematics makes it easier to understand the relationship methodically and to draw particular conclusions that would be difficult to get at through oral arguments or would necessitate time-consuming, difficult, and complex processes. These days, economic analysis relies heavily on mathematics. Through the use of mathematics, different economies can be better understood. Mathematical tools can be used methodologically to investigate economic problems. A common term for this approach is mathematical economics.

First and foremost, the volume's engaging and instructive material deserves praise. As Weintraub correctly noted, there is a gap in the history of economics and the circumstances that have influenced it: the development of mathematics and its connection to economics. Regardless of one's level of mathematical experience, this could be educational. For those who learnt mathematics indirectly through economics, there are important insights into the subject. Like economics, maths is a diverse field whose nature and uses have changed over time. However, methodological awareness does not emerge frequently in economics or mathematical education. Thus, those who approach economics through mathematics can also learn a little bit about our history, which helps them better comprehend how the different fields relate to one another. Thus, Weintraub uses his thorough knowledge of the history of both disciplines to successfully educate his audience about the theory of mathematical economics. So, we will be talking primarily about how we might use the new understanding he has given us. Weintraub's approach to his material is the subject of the first concern, which is reflexivity.

This volume illustrates one of the most famous historiographic techniques developed by Weintraub. He has stated repeatedly that he believes that multiple historical accounts of the same periods or events can be given; selecting one as the "best" narrative is impossible. Similarly, there are numerous approaches to historiography, including scientific investigations.

In his opinion, these stories are better produced outside of the pertinent subject in order to avoid interpreting history in terms of modern concepts and to address modern issues. As a result, Weintraub's approach to his subject and its conclusion poses significant difficulties. The historiographical approach is thus the primary emphasis of this book.

LITERATURE REVIEW

Numerous attempts were made before to Cournot to use mathematical analysis to explain economic concerns. These efforts began in the early eighteenth century. The classical, physiocratic, and mercantilist schools don't seem to be attempting to use mathematical analysis in any meaningful way. Despite the mercantilist literature's frequently encouraging recognition of correlations between various values, these relationships are not mathematically applied (Robertson, 1949, p.523). In his 2013 book "Mathematical Statistics for Economics and Business," Hoeft R. described how to use mathematical statistics in economics for business management research. Daniel Breslau (2003) detailed in his research paper, "Economics Invents the Economy: Mathematics, Statistics, and Models in the Work of Irving Fisher and Wesley Mitchell," This book examines the social roots of some of the developments in economic theory, particularly the mechanical models and statistical indicators that contributed to the formation of the economy. A wide range of topics pertaining to statistics, mathematics, education, social science, and economics have been covered in the book "Mathematical Statistical Models and Quantitative Theories for Economic and Social Sciences" by S. Hoskova Mayervo et al. (2003), which reflects the complexity and heterogeneity of economic and social phenomena. As a result, a variety of tools and techniques that can be used to solve problems pertaining to these topics have been fully described. Dividend-price ratios are a statistically partial predictor of returns and consumption growth, as stated by Ravi Bansal et al. (2007) in their paper "Predictability Economics and Statistics." Return and cash flow predictability have been highly debated topics in finance for many months. The long-run hazards model supports the idea that returns and consumption growth are reasonably predictable. In 2007, Winker P. and Maringer D. described threshold accepting (TA), a powerful optimisation technique from the evolutionary algorithm genre. Numerous examples from the fields of economics, econometrics, and statistics are used to clarify and demonstrate the issues with TA implementations. Chih M. et al. (2011) compared the results with those from the Genetic Algorithm under the same conditions and discovered that the Genetic Algorithm, a popular evolutionary technique in the field of control charts, was a promising method for resolving the problems inherent in the economic and economic statistical designs of a mean value control chart. In 2019, Thomas Cleff gave talks on presentation, scaling, advanced multivariate analysis, and fundamental univariate analysis of quantitative data. In his research, Dale J. Poirier looked at how the terms "Bayes" and "Bayesian" have been used in journal articles from a variety of academic disciplines from 1970, with a focus on economics and statistics.

MATHEMATICAL ECONOMICS

A subfield of economics known as mathematical economics develops economic theories and examines economic issues using mathematical techniques. Economists can do measurable experiments and create models to forecast future economic growth with the aid of mathematics. Quantitative approaches are now a basic component of economics thanks in large part to developments in computing resources, big-data methodologies, and other cutting-edge mathematical technology. The research of economics is advanced by scientific approaches that support each of these components. Mathematical economics is a brand-new area of econometrics that combines statistical techniques, mathematical concepts, and economic theories. Mathematical economics uses statistical facts to support, refute, or predict economic behaviour. Despite the fact that researcher bias has a significant impact on economics, mathematics provides the foundation for theoretical interpretation and allows economists to characterise observable phenomena. To make economic phenomena meaningful in the past, economics mostly depended on situational theories or anecdotal evidence. But because mathematical economics developed methods for measuring economic shifts, the majority of economic theories now have some type of statistical support. Real economic modelling has been made possible by mathematical economics, which makes theoretical economic models' practical tools for daily economic policymaking. The overall goal of econometrics is to convert qualitative claims into quantitative ones. When it comes to tackling optimisation difficulties, mathematical economics is particularly helpful. To influence a specific result, a policymaker can, for instance, search for the most effective adjustment among several options.

UNDERSTANDING THE ROLE OF MATHEMATICS IN ECONOMICS

When deciding whether to pursue a particular job, it can be helpful to have a better understanding of the fundamental elements that comprise a sector. Examining the components of the discipline, such as the use of mathematics in economics, can be helpful when thinking about a career as an economist. An aspiring economist may benefit from having strong mathematical abilities because there are areas of the field dedicated to using maths to enhance performance. This article describes the function of mathematics in economics, explains its applications, outlines the sorts of math economists utilise, and demonstrates why math is crucial for economics. Using mathematics, economists can create models and carry out quantitative experiments to predict future economic growth. The adoption of quantitative methods as a fundamental aspect of economics has been greatly aided by large-data approaches, computer power, and other state-of-the-art mathematical technologies.

a) The function of economics and mathematics

All branches of economics use mathematics, but mathematical economics is the one where it is most frequently used. Economists that specialise in mathematical economics apply mathematical ideas to economic theory. An economist may combine the use of mathematics with other tools and strategies, like computer algorithms and data collection.

b) Mathematical significance in economics

The application of mathematics in economics enables an economist to provide more accurate forecasts and analyses. This might enable them to draw more conclusions from their analysis's findings. It is also possible to lessen the possibility of bias and economic estimates by using quantitative data and mathematical computations. As the use of computers in economics has grown, so too has the significance of mathematics. Economists can process increasingly complicated mathematical equations or vast volumes of data more readily thanks to computer technology. With computers making complicated calculations easier to perform, this broadens the application of mathematics in economics and might make it a more desirable career path.

1. Types of math in economics

You may employ a variety of mathematical techniques when working as an economist. In economics, the most prevalent types of mathematics are:

a. Algebra

A fundamental area of mathematics, algebra forms the basis for numerous other types of mathematical computation. With algebra, one may solve equations involving one or more variables and determine the outcome for a variable under specific circumstances. Algebra is a helpful mathematical ability for projection and computation for an economist. An economist can accomplish tasks like establishing a target growth rate and using an established equation to solve for the necessary linked variables to obtain that rate by working with variables.

Related: Definitions, Types, and Examples of Algebraic Mathematical Equations

b. Calculus

Calculus is a branch of mathematics that studies rate-of-change computations. A lot of high school curriculum include basic calculus courses. If a student wants to work in mathematics, they can also seek further education while still an undergraduate. An economist can use calculus as a valuable tool for forecasting and evaluating economic performance. You can see trends and make better decisions by using calculus to create curves based on economic data. When working as an economist, you can use this for tasks like supply and demand analysis, market evaluation, and economic forecasting.

c. Probability

Probability is a branch of mathematics that quantifies the possibility of a particular event or result. By using probabilistic evaluation, a mathematician can determine the likelihood of a prospective outcome and evaluate the relative chances of two or more possible events. It can be helpful for economists to grasp probability when estimating the likely outcomes of economic decisions. The expected cost or benefit of an economic strategy can be calculated by multiplying the probability of several possible outcomes by the estimated cost or benefit of each result.

d. Statistics

The study of statistics is a branch of mathematics that focusses on gathering, organising, and analysing data sets. A mathematician can use it to evaluate a population that is represented in the data. For jobs like projecting and modelling responses or behaviours within a society, that is an essential talent. Because statistics enables you to work with vast volumes of data, it is a useful mathematical skill for economists. By doing statistical computations on datasets, you might be able to find important patterns or details about how people are grouped within a community. When suggesting plans or policies, you or others in decision-making positions can utilise this information as a guide.

i. Functions

The relationship between two or more variables is explained by a mathematical function. Stated differently, a function describes the relationship between one or more variables. A variable's value can therefore be expressed mathematically as y = f (x) if it depends on another variable, x. According to the assertion, every value of the variable y is dependent upon a unique value of the variable x. In the function y = f(x), x is the independent variable and y is the dependent variable. In economics, price determines demand, whereas the factors of production determine production. To put it simply, we say that demand (D) is determined by price.

ii. Differentiation

Rate measurer: "Synonyms" are a mathematical concept that underpins most economic decisions. This process is known as "marginal analysis." In economics, the concept of "margin" is essential. If U = f(Q) is the total utility function, then the marginal utility is the first-order derivative of the total utility function. For example, du/dq Similarly, all marginal concepts, including as marginal productivity, marginal income, marginal cost, marginal propensity to save (MPS), and marginal rate of substitution (MRS), are determined by the first-order derivatives of the relevant functions. To put it briefly, differentiation can be used to separate the marginal functions from the overall functions.

iii. Slope

The value of dy/dx represents the gradient or slope of a curve in graph form. The "rate of change" or "slope" of curves that depict demand, revenue, cost, and indifference can be found using this technique in economics.

iv. Parabola

The quadratic function, also referred to as the second-degree function, is another mathematical concept. The graph of this function resembles a "parabola," or U. This method is employed in cost "functions" in the study of economics since cost curves are U-shaped.

v. Economics is a Social Science

The economic situation is not the only thing it describes. It forecasts the potential effects of various changes on particular economic variables, such as the effects of crop failure on crop prices, the effects of a sales tax increase on the cost of finished goods, and the effects of increased government spending on unemployment. It seeks to elucidate the workings of the economy. It also suggests certain guidelines for efficient resource distribution that governments, corporations, and other economic actors could follow. A strong grasp of mathematics is necessary for any significant application of economics to these domains. A summary of economists' (qualitative and graphical) methods and perspectives can be found in Applications of Mathematics in Economics. It increases the applicability and tangibleness of economic laws and relationships.

2. Economic applications of mathematics

Maths can be used for many different career goals if you work in economics. In economics, some of the most popular applications of mathematics are as follows:

a) Analysis

One of the main duties of an economics practitioner is analysis. Evaluating data on markets, economic performance, and other important economic information and drawing conclusions from it are common tasks in economics. This enables people to use data from multiple sources while making economic judgements. Numerous types of data analysis heavily rely on mathematics. This can involve both basic mathematics used for activities like calculating averages and more complex mathematics like differential equations. An economist can perform their analytical task more efficiently if they possess strong mathematical talents in a variety of mathematical domains.

Associated with: Knowing Economics: Types, Indicators, and the Significance of Economists

b) Modeling

Key economic data can be visualised using an economic model. People may find it simpler to visualise or comprehend the condition of an economic market when they use a model. Additionally, a model might give data a new format that delivers insights not seen in the raw dataset. When developing an economic model, as an economist, you will probably need to apply your mathematical knowledge. When you build a model, accurate math gives you trustworthy data that can raise the model's value when it's finished.

c) Projection

Forecasts of future economic trends and behaviour are provided by economic projections. Economists find accurate forecasts to be a useful tool because they enable them to base their future planning decisions on the future state and behaviour of the market. Making economic estimates requires a lot of maths. It enables an economist to make calculations on economic data, frequently evaluating possible changes in the data over time using calculus concepts. By making sure you perform your calculations accurately and increasing the number of calculations and mathematical concepts you comprehend and can use in your job, improving your mathematical abilities as an economist will help you increase the accuracy of your calculations..

Statistics' function in economics

The field of statistics include the gathering, organising, analysing, interpreting, and presenting of data. Statistics are essential for comprehending economic data, including the connections between both price and quantity, market demand and supply, economic production, GDP, and national per capita income, among other topics.

a) Central Tendency Measures [9, 10, 11]

A single value that aims to depict a collection of data by identifying what is happening inside that collection of data is a segment of the central tendency. As a result, they are commonly referred to as focal arrangement estimates. They are also thought of as outlining insights. Perhaps the focal propensity metric that you are most aware of is the normal, also referred to as the mean, but there are also the middle and the mode. Even though the mean, middle, and mode are reliable indicators of focal inclination, some situations make some of these indicators more important than others. In the next sections, we will examine the mean, mode, and middle, as well as determine how to calculate them and when they are typically useful.

i. Mean

The most well-known and significant focal propensity estimation is the mean, which is frequently referred to as the normal. It can be used with both continuous and discrete data, but it is most commonly used with continuous data (see our course on the Different Types of Variables for additional information on data types). The mean is calculated by dividing the total number of values in the informational collection by the total number of values included.

Formula: $$\mathbf{A.M} = \frac{\sum \mathbf{fx}}{\mathbf{N}}$$

ii. Mode

IIn measures, the value that appears most frequently in a given set is referred to as the mode. In an information assortment, a mode or modular worth is a value or number that appears as frequently as possible or with a high recurrence. It is one of the three focal propensity proportions, together with the mean and middle. As an illustration, the technique for sets 3, 7, 8, 8, and 9 is 8. It is then straightforward to determine the mode for a little information arrangement. There may be one mode, several modes, or no modes at all in a worth set.

Formula:

$$\mathbf{M_o} = \mathbf{l} + \frac{\mathbf{f - f_{-1}}}{\mathbf{2f - f_{-1} - f_1}} \times \mathbf{i}$$

iii. Median

In an ordered, ascending, or descending sequence of numbers, the middle number is the centre one.

This might make the informational gathering more captivating than usual. The midway of the data is the point above and below which half (or 50%) of the observed data falls.

$$\text{. Formula : } \mathbf{M_d = l + \frac{\frac{1}{2}N - F}{f} \times i}$$

b) Dispersion Measures

Even while two data sets have the same mean, they may be very different. Therefore, in order to describe data, one needs to be aware of the degree of variability. This information is provided by the dispersion measures. Standard deviation, range, and interquartile range are the three most commonly used measures of dispersion.

i. Range

The difference between a data set's highest and lowest values is known as the range in statistics. For example, if the given data set is 2, 5, 8, 10, 3, the range will be 10 minus 2 = 8. Formula: $R = R_g - R_1$

ii. Quartile Deviation

The mathematical definition of the quartile deviation is half the difference between the upper and lower quartiles. Here, the phrase "quartile deviation" can be applied; Q3 represents the upper quartile, and Q1 represents the lower quartile.

The quartile deviation is also known as the Semi-Interquartile range.

$$\text{Formula : } \mathbf{Q.D = \frac{1}{2}(Q_3 - Q_1)}$$

iii. Average Deviation

One of the several changeability records that analysts use to illustrate the distribution of estimates within a population is the usual deviation. The usual deviation of a collection of scores can be obtained by tracking the mean and then the specific distance between each score and that mean, regardless of whether the score is above or below the mean. Another name for it is a typical blatant deviation. The average deviation can be calculated using the formula below.

$$\text{Formula: } \boldsymbol{\sigma} = +\sqrt{\frac{\sum \mathbf{f(x-M)^2}}{\mathbf{N}}}$$

iv. Standard Deviation

The degree of variation (including scattering, spread, and spread) from the mean is shown by the standard deviation measurement. The "typical" deviation from the mean is shown by the standard deviation. Because it returns the original units of measurement from the data collection, it is a popular variable. As with variance, there is a little variation when the data points are near the mean and a large variation when they are far from the mean. The degree to which the values diverge from the mean is determined by the standard deviation. The most widely used metric of dispersion, standard deviation, is computed using all data. Consequently, even a single value change has an impact on the standard deviation's value. It lacks commencement but not scale. Additionally, it can be applied to answer some intricate statistics issues.

$$\text{Formula: } \boldsymbol{\sigma} = +\sqrt{\frac{\sum \mathbf{f}(\mathbf{x}-\mathbf{M})^2}{\mathbf{N}}}$$

v. Variance

The degree to which a collection of data is uniformly distributed is measured by its variance. There is no variance in the data if all of the values are the same. Any variance more than zero is considered positive. A low variance indicates that the data points are near the mean and each other, as opposed to a high variance, which implies that the data points are widely separated from both. The variance can be defined as the sum of the squared distances between each point and the mean. is the proportion of the degree to which different types of information are spread out. There is no variance in the data if all of the values are the same. Any variance more than zero is considered positive. A slight shift suggests that the information focusses are near the mean and each other, whereas a considerable fluctuation is shown if the information focusses are disproportionately spread apart from the mean and from one another. Consequently, the squared departure from each highlighted mean is used to characterise the difference.

Variance Formulae:

The population variance formula is given by: $\sigma^2 = \frac{1}{N}\sum_{i=1}^{n}(X_i - \mu)^2$ sample variance formula is given by: $s^2 = \frac{1}{n-1}\sum_{i=1}^{n}(x_i - \bar{x})^2$

vi. Correlation

One way to find relationships between two variables is to use correlation. You examined the link between two variables using a "dissipate plot" to see if they were related. Although the link is the most frequently used approach, there are numerous proportions of association for elements that are assessed at the ordinal or higher level of estimation. A certain or negative association coefficient that is very near to zero indicates that there is almost no relationship between the two components. The two elements are said to be positively associated if the connection coefficient is near to one, meaning that changes in one variable are linked to changes in the other. An increase in one element and a reduction in the other indicate a negative association, as indicated by a relationship coefficient close to -1. While a relationship coefficient may have components that are evaluated on a scale such as apparent, ordinal, range, or extent level, its significance is modest. The association coefficient for ordinal scales can be found using Spearman's rho. The correlation coefficient, commonly referred to as Pearson's r, is the most commonly utilised statistic for interval or ratio level scales.

vii. Coefficient of Correlation

In statistics, a coefficient of correlation is commonly used to ascertain the link between two variables. Numerous connection coefficients exist, each of which denotes a distinct motivator for the degree of the direct relationship between components X and Y, or X and Y. However, in direct relapse, the connection coefficient that is frequently used is Pearson's connection, also referred to as Pearson's R. To illustrate the example connection coefficient, use the following equation:

$$r = \frac{\sum\left[\left(x_i - \bar{x}\right) * \left(y_i - \bar{y}\right)\right]}{\sqrt{\sum\left(x_i - \bar{x}\right)^2 * \left(y_i - \bar{y}\right)^2}}$$

viii. Pearson's Coefficient Correlation

A sophisticated numerical method called Karl Pearson's coefficient of connection is used to calculate the degree of connection between two factors that are directly related. "r" stands for the correlation coefficient. The Karl Pearson's Coefficient of Association, also known as the Karl Pearson's Coefficient of Relationship, is a measure of an immediate association that ranges from -1 to +1 in regard. A value of +1 indicates a strong positive association, whereas a value of -1 indicates a strong negative relationship.

Formula : $$\mathbf{r} = \frac{\sum \mathbf{xy}}{\sqrt{\sum(\mathbf{x})^2 \sum(\mathbf{y})^2}}$$

ix. Spearman's Rank Correlation Coefficient

With the ultimate goal that $-1 \leq r < 1$, Spearman's position relationship coefficient, represented by r, is a mathematical value. It provides a percentage of the likelihood that one variable will increase as another builds (an instantaneous affiliation) or that one variable will decrease as another expands (a backward affiliation). Inverse relationships are indicated by negative values, whereas direct associations are indicated by positive values. No relationship is indicated by a value of 0. The stronger the association, the closer r is to 1 or 1, and the weaker the association, the closer r is to 0. Rank connection coefficient upsides of 1 or -1 indicate that the positions are either immediate alternate extremes ($r = -1$) or concur ($r = 1$).

Formula: $$\mathbf{r} = 1 - \frac{6\sum \mathbf{d}^2}{\mathbf{n}\left(\mathbf{n}^2 - 1\right)}$$

GOALS FOR THE STUDY

1. To investigate the application of mathematical concepts in economic theory.

2. To note the various applications of mathematical tools in the study of economics.

TECHNIQUES

The author cites all of the books, journals, papers, and websites. The use of mathematical tools and methodologies to economic theoretical issues is illustrated.

CONCLUSION

Maths is used all around the world. Mathematics is essential to both business and economics. Without mathematics, one feels helpless in every aspect of economic relations. Therefore, calculus is necessary for figuring out taxes, profit, and revenue—all of which are vital for any type of business. There are two reasons to apply mathematics to economics: first, it gives you the mathematical knowledge you need to create and understand economic arguments; second, it makes you feel comfortable while utilising mathematical jargon to describe economics. It is methodologically feasible to investigate economic issues using mathematical techniques. This approach is commonly known as mathematical economics. Mathematical economics is the study of economic ideas and problems through the application of mathematical methods. Thanks to mathematics, economists may develop significant, testable ideas regarding a variety of complex subjects that are more challenging to explain casually. Differentiating Rate measurer: The majority of economic decisions are based on "Derivatives," a field of mathematics. Slope: The value of dy/dx graphically represents the gradient, or slope, of a curve. The quadratic parabola Function, also referred to as a second-degree function, is another mathematical notion. The graph of this function is called a "parabola." Functions: A mathematical function describes the relationship between two or more variables. Examining basic mathematical tools commonly used in economics research, such as econometrics, macroeconomics, and microeconomics, is the aim of this paper. Economic concepts are inadequate if they are not supported by mathematical applications. For a proper knowledge of every economics topic, mathematics must be applied. By using mathematical techniques to make economic concepts understandable, one may become more interested in the subject.

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