An Impact of Mathematical Modeling in Economic Growth in Nigeria

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ABSTRACT

Mathematical modeling is a method for imitating real-world situations using mathematical equations and predicting their future behavior. It uses techniques like decision theory, queuing theory, and linear and nonlinear programming, all of which need a significant amount of processing. These models are used by economists to simplify reality. It is easier to comprehend economic challenges when data is represented using models. Models are important in economics because they calculate numerical concerns, display data in a comprehensible way, and explain how the process works. Econometrics is a subject that is used to forecast economic trends and establish new economic concepts. Econometricians employ a high level of mathematical expertise to explain and predict economic difficulties.

This study examines the influence of mathematical models on economic growth. We discovered that using mathematical models helps organizations make better use of their resources, which leads to improved production, which benefits the organization's and country's finances.

(Keywords: mathematical modeling, flowchart, graph, diagrams, exponential model)

INTRODUCTION

A mathematical economic model is a formal explanation of precise relationships between quantities such as pricing, production, employment, saving, and investment in order to examine their logical consequences. Some of these connections are based on empirical facts, while others are based on theoretical axioms about the expected behavior of a "rational" economic actor known as the *homo economicus*.

The relevance and utility of the analysis' outcome are defined by the validity of the model's premises and our ability to uncover all of its ramifications, assuming no mathematical errors are made. The eventual utility of the analysis' conclusions is strongly dependent on the model's underlying hypotheses, regardless of how complicated the mathematical tools used in the analysis are. To put it frankly, the adage "junk in, garbage out" still applies to mathematical economics, as it does to every other scientific area. This self-evident reality, on the other hand, is not an argument against the use of mathematics to economic theory.

In most cases, intuition and common language are insufficient tools for delving into tough and complex situations since the implications of assumptions are frequently buried and inconsistent. Under these conditions, mathematical reasoning must be supplemented and strengthened. "You can become a brilliant theorist without knowing mathematics...[but]...you will have to be more clever and smart," said Nobel Laureate in economics Paul Samuelson in 1952. This point was highlighted forcibly by Jacob T. Schwartz, a well-known contemporaneous mathematician who wrote extensively on economic subjects (see, (1961)).

We will summarize his major thesis from an unpublished paper, examine disagreements over whether a proposition is true or false (based on supplied axioms), and look at mathematical formalisms, disciplined mathematical reasoning, by defining a domain in which patterns of reasoning are reproducible and objective. Even though there have always been ardent champions and detractors of utilizing mathematics in economic analysis, there is now universal agreement that the discipline imposed by mathematics on economic reasoning played a fundamental influence in the formation of economic theory as a science.

However, it is frequently forgotten that "hard" sciences such as physics rely on the methodical application of two methodologies to establish objectively true scientific propositions: (i) consistency, which entails adhering to a set of formal rules established by mathematics; and (ii) experimental verification, which entails confronting observable statements created by a mathematically coherent theory with the real world. The fact that most economic concepts and reasoning are abstract and "cannot be translated into English," as Mashall observed, is not what makes economic theory unsatisfactory as an experimentally valuable subject. It's more about the fact that the accuracy of many of the theory's assumptions cannot or have not been rigorously checked empirically.

It took a long time to present mathematical methods to economics. Outstanding mathematicians such as Bernoulli, Gauss, Laplace, and Poisson developed truly mathematical models to discuss economic problems in the XVIII and early XIX centuries, and Aristotle's work (see Theocaris, 1961) contains examples of essentially mathematical reasoning applied to economic problems. Cournot's (1838) fundamental (and long-ignored) research on microeconomic theory, on the other hand, is often regarded as the birth of contemporary mathematical economics.

The publication of Leon Walras' famous *Elements Economie Politique Pure* in 1874 is associated with the ultimate dominance of the so-called neoclassical school in the economic profession, particularly with the concept of competitive general equilibrium (see Walras,1926). Since then, mathematics has been used to practically every aspect of economic research, and the interval between the publication of new mathematical (and statistical) findings and their application to economics has been significantly reduced.

The majority of new mathematical ideas and discoveries have been inspired by earlier mathematical achievements or physics-related problems. Because of the mathematical intricacy of the problems given by economic theory (and economic life), mathematicians (or mathematical economists) have progressively produced new concepts and ways to solve them, as well as extended and modified existing ones. Outstanding examples of this phenomenon may be found in John von Neumann's writings on economic development and game theory, Kenneth Arrow and Gerard Debreu's writings on general economic theory, John Nash's writings on game theory, and Frank Ramsey's works on optimum theory of saving. Despite his efforts to avoid any difficult formalism, Piero Sraffa is particularly well known for enlisting the assistance of top mathematicians such as Abram Besicovitch and the aforementioned Frank Ramsey throughout the lengthy gestation of his opus Production of Commodities by Means of Commodities.

Mathematical and geometrical methodologies were utilized at a lower degree of sophistication to create Keynesian macroeconomic theory, which dominated the topic following the Great Depression, and in part as a reaction to it, until the 1970s. The so-called "IS-LM model," devised in the 1930s by John Hicks and Alvin Hansen and quickly adopted as the standard macroeconomic equilibrium formulation, is a notable example of this.

The purpose of this study is to introduce several economic and economic analysis models. Other advanced models exist, however, this study focuses on a few simple and common models as well as their applications.

- What exactly are economic models, and how do they function?
- What distinguishes them from one another?
- What do economists do with them and when do they use them?
- And, perhaps most importantly, why do economists want models at all?

All of these questions will help you better grasp the role and significance of economic models. The parts that follow will go through these topics in greater depth.

What is a ‘Model’?

It is best to begin with a model definition. One definition of a model in Hornby's (2000) Oxford Advanced Learner's Lexicon is as follows:

“A model is a simplified depiction of a system used to explain how something works or compute what can happen, such as a mathematical model for predicting safe pesticide dosage in food or a realistic evolutionary process".

A model can be used for a variety of reasons, including system description and calculation, as illustrated by this definition. Many economists have different notions about what constitutes an economic model. The definitions below are drawn from a few economic textbooks. According to Samuelson and Nordhaus, a model is a formal framework for capturing the fundamental elements of a complex system through a few central linkages (1998). Graphs, mathematical equations, and computer programs are examples of models.

A model or theory, according to Begg, Fischer, and Dornbusch (2000), makes a series of simplifications from which it deduces how individuals would behave. It's a purposeful concealment of the truth. Models are used by scientists and mathematicians in the problem-solving and problem-analysis processes. Economists, too, utilize models to research and demonstrate economic problems. Mathematicians in this subject create and simplify a model (a collection of mathematical equations) to explain how the entire system works, then use the model to calculate and predict what will happen if the system continues to operate under the same conditions. Econometrics, like mathematical modeling, is an economics discipline that uses statistical tools to quantify and estimate quantitative economic connections. Samuelson and Nordhaus (1998) describe an econometric model as follows:

An econometric model is a collection of equations that reflect economic activity using historical data. Econometricians have built a whole industry around estimating macroeconomic models and forecasting the economy's future. Many of them created computer programs to help them solve the complex system of mathematical problems. In the following section, we'll go through the many sorts of economic models in further detail.

Types of Models in Economics

Models in economics can take many different forms, according on the definition, including graphs, diagrams, and mathematical models. Economists use these models for a number of reasons, based on factors such as the sort of raw data available, how the data might be represented, and what they expect from the model. This section will provide further information about the major roles of these diverse models, as well as some pertinent economic examples.

Flow Chart

A flow chart is a diagram that displays the relationships between different stages of a process or system elements. Flow charts are used by economists to demonstrate how the economy operates and how its members interact with one another. It will be easier for users to grasp the relationships of economic participants if they follow the correct linkages in the flow chart diagram.

Figure 1 depicts a circular-flow diagram, which is an important flow chart in economics. A circular-flow diagram is a graphical representation of the economy that displays how money transfers between people and firms in the market

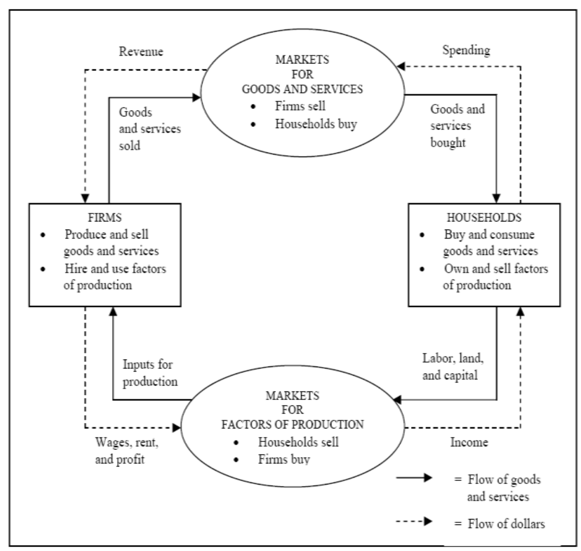

Figure 1: Circular Flow Diagram.

Graph

A graph is a plotted drawing that displays the relationship between two or more sets of numbers using a line or lines. Graphs of a single variable, such as pie graphs, bar graphs, or time-series graphs; graphs of two variables (represented by x and y coordinates), such as scatter diagrams; and graphs of more than two variables, (these graphs are represented by more than 2 coordinates). In economics, many different graphs are used: some demonstrate how variables change over time, while others show the relationship between different variables. As a result, it is vital to grasp the distinctions between different graphs and how to select the best one to display observable or fascinating data.

While there are numerous additional types of graphs, it is best to focus on the most popular types of graphs used in economics. The following section discusses many graphs used in economics, including the production possibilities frontier (PPF), time-series graphs, scatter diagrams, and multicurve diagrams.

The production possibilities frontier, or PPF, is a graph that displays the many output combinations that the economy could generate given the available production components and technology.

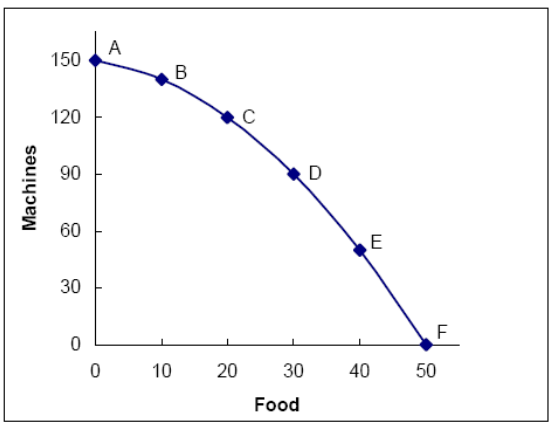

Figure 2: Production Possibilities.

Frontier

Figure 2 depicts the six possible pairs of food-machine production levels. A smooth curve filling in between the plot pairs of dots create the production possibilities frontier.

Time-series graphs show the evolution of a variable across time. A time-series graph has a horizontal axis that represents time and a vertical axis that shows the variables of interest. A time-series graph used in economics is the debt-to-GDP ratio.

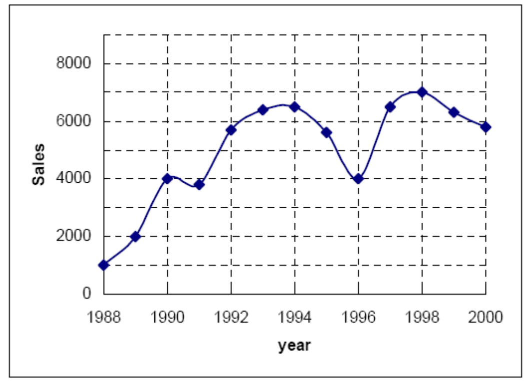

Figure 3: Time-Series Graph.

Figure 3 shows a particular company's sales from 1988 to 2000.

Scatter diagrams show data for two variables. In certain cases, only individual pairings of dots will be depicted; however, scatter diagrams are commonly plotted as a mix of variables throughout multiple time periods (month, year, etc.). In macroeconomics, the consumption function is an excellent example of a scatter diagram.

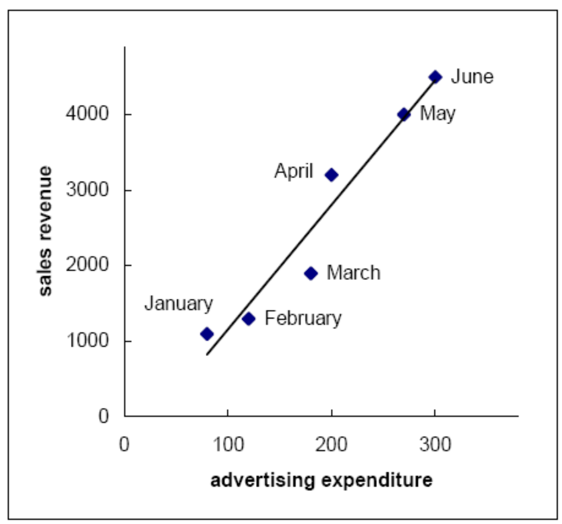

Figure 4: Scatter Diagram.

Over the course of six months, this graph demonstrates the relationship between a company's monthly advertising budget and monthly sales income. The line in the scatter plot represents the data trend.

Multicurve diagrams represent two or more relationships in a single graph. In many cases, utilizing just one curve in a graph to analyze a complicated economic system is insufficient. As a result, displaying numerous curves in a single graph will be advantageous in order to see the relationship between them. Figure 5 depicts the most essential example of a multicurve diagram: the supply-and-demand diagram

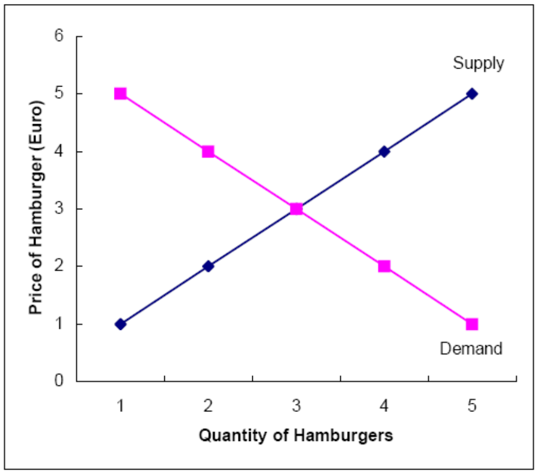

Figure 5: Supply-and-Demand Diagram.

This graph shows the relationship between the number of hamburgers sold and the price of a hamburger, as well as the supply and demand curves.

Mathematical Model

A mathematical model is a formulation or equation that explains the key elements of a physical system or process in mathematical terms. It can be defined as a form's functional relationship in a broad sense.

f = dependent variable (independent variables, parameters, and forcing functions) **(1)**

The independent variables are normally dimensions, such as time and space, along which the system's behavior is being defined; the parameters are reflective of the system's attributes or composition; and the forcing functions are external effects operating on it. From simple algebraic relationships to enormous sets of differential equations, Equation (1) can be stated mathematically in a variety of ways. Economists use a mathematical model known as a 'theory' to determine the specific problem.

Many well-known mathematical models, such as the rule of 70, are used as formulas in economics to help economists calculate and understand numerical challenges. Econometricians use scientific thinking to the creation of new econometric models or theories in order to better understand the economy. When creating a model, it's a good idea to write down all of the components that are related to the economic problem being researched; otherwise, some influencing factors that could cause difficulties inside the model may be overlooked. Later, we'll delve more into how economists develop models. An example of an econometric model is the one used to forecast GDP.

Why do Economists Need a 'Model'?

To answer this topic, you must first understand how economists evaluate, solve, and foresee economic problems. Economists, as previously said, take a scientific approach to tackle economic problems. The scientific method begins with scientific observation (which can include the environment or other fields of interest), is followed by the development of a hypothesis, is followed by the use of scientific experimentation or existing theories to prove their hypothesis, and finally, they arrive at a conclusion that can be true or false (it depends on the results from their experiment).

When economists consider a particular economic issue, they try to simplify it so that everyone can understand it and follow their reasoning; they look for a formula to help them calculate the numerical issue; and they try to develop a new economic theory to explain economic behavior in the real world. What do they need to implement these strategies? They do, in fact, require a tool to aid them, which is referred to as a 'model' in this context. Models are used by economists for three purposes: to describe an economic process, to explore an economic issue, and to develop a new economic theory.

Explaining an Economic Process

The Chinese proverb "a picture is worth a thousand words" states that an image can communicate a subject better than words or mathematics. Economists can use graphics for a variety of objectives, including demonstrating how the economic process works and depicting trends using historical data. Graphs and flow charts are critical in this use of models. The production possibilities frontier depicts the relationship between available production factors and available production technology; the circular-flow diagram depicts how money flows through the market between households and businesses; and the famous supply-and-demand diagram depicts the relationship between demand and supply curves in the same frame.

They can use these models to visualize the process, understand how data is related to one another, and gain a better understanding of the issue. These models will be used in conjunction with mathematical models to achieve a number of goals.

Examining an Economic Issue

What do economists aim to gain from the data they collect? They are interested in not only how the system appears or how the relationship is graphically represented, but also the data's trend or changes. To examine economic difficulties, economists utilize a variety of mathematical models: some simple formulae are used to generate a new value or evaluate data; some mathematical models are employed in the problem-solving process; and some equations are used to estimate and forecast economic development.

Begin by developing a simple mathematical equation that may be used to calculate and measure economic changes such as percentage change and growth rate.

To get the percentage change, divide the absolute change by the original amount and multiply by 100.

In most publications, economic data is expressed as a percentage. When data is evaluated over time, the growth rate, or percentage change each period, is approximated (typically per year). Economists utilize economic growth (the annual percentage change in a country's or set of countries' national income) to monitor, assess, and anticipate a country's trend and economic status. Second, in the problem-solving process, a model is necessary. The issue specification, mathematical model, numerical or graphic outcome, and implementation are the four steps in this approach (Figure 6).

In addition to a mathematical model, visuals, statistics, and other problem-solving tools are used in the problem-solving process.

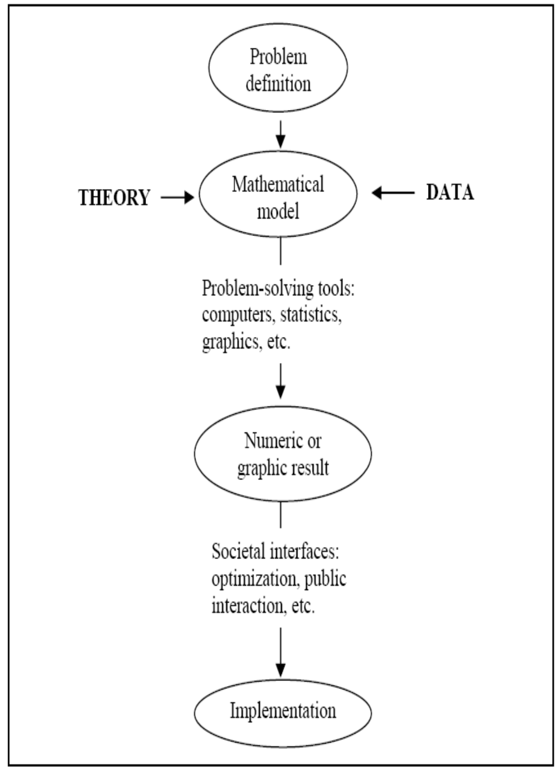

Figure 6: Problem Solving Process.

Finally, certain models are employed in order to forecast and estimate future developments. Economists have created forecasting tools to assist them in forecasting economic changes. Forecasting models are created as a series of equations by combining mathematical models and historical data.

Currently, large systems can forecast between a few hundred and 10,000 variables. Although this is the primary goal of econometrics, forecasting is a difficult task. GDP forecasting is an example of critical forecasting. Forecasting results are not always precise; errors can occur depending on how well the system of equations is built and how many variables are included in the model.

Developing a New Economic Theory

Finally, specific models are used to forecast and estimate future trends. Economists have developed forecasting methods to help them foresee economic changes. Forecasting models are built as a sequence of equations from mathematical models and historical data.

Large systems can currently forecast between a few hundred and 10,000 variables. Although this is the primary goal of econometrics, forecasting is a difficult task. Critical forecasting is an example of GDP forecasting. Forecasting results are not always accurate; errors can occur depending on how well the equation system is constructed and how many variables are included in the model.

$$y(t) = y_0 e^{kt} \quad \textbf{(2)}$$

Where y(t) represents the quantity present at any time t; y0 represents the amount present at some initial time t = 0; and k (k > 0) represents the growth rate.

Exponential growth models have been found to be beneficial in population growth investigations (for forecasting purpose). The doubling time is a useful application of the exponential growth concept. The doubling time is the time it takes for a quantity y to double in size if it has an exponential growth model. The quantity present at the start has no bearing on the time it takes to double. We can construct Equation (3) using the mathematical method by assuming that the amount y has an exponential growth model.

$$T = 1/k \ln 2 \quad \textbf{(3)}$$

T is the time it takes for y to double in size; k (k > 0) is the growth rate; and ln 2 = 0.6931. This applied strategy is known as the rule of 70 in economics. While the approximate value of ln 2 is 70, when divided by the percentage change, a length of time is required for the initial quantity to double in size. It has been demonstrated that developing a formula is not straightforward, despite the fact that the formula itself appears to be quite simple, thanks to the genesis of the rule of 70.

CONCLUSION

Previously, we looked at 'What is a model?', 'Types of economic models', and 'Why do economists require a model?' These topics provide a more in-depth understanding of the role of models in economics. Without models, how can economists explain their ideas in a way that others can follow and understand? It is difficult to describe any economic issue without utilizing graphs, diagrams, or math.

Economists use these models to perform their research. Their fundamental goal is to make reality more understandable. When data is represented using models, it is easier to grasp economic difficulties. Models are useful in economics because they analyze numerical issues, display data in a visual format, and explain how the process works.

Econometrics is a branch of economics that is used to forecast economic occurrences and create new economic ideas. Economists use advanced mathematical skills to explain and forecast economic problems.

In economics, there are various criticisms of models. For example, there is a distinction between models and the objective of employing models; models are used to simplify reality, but the majority of them are difficult to understand and are always presented using intricate systems of equations. There is no true or false agreement on this topic; models should not only be clear and easy to comprehend, but they should also cover all impacted areas in order to avoid errors.

Models are commonly used in economic reports and research. Models are important in economics because they give economists with tools as well as guidance on how to use them properly. They defined econometrics as a discipline of economics to allow for more in-depth investigation into models. These conversations highlight the importance of models in economics.

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