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The Role of Mathematics in Economics: Necessity or Contradiction?

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Abstract

This study addresses the relationship between economics and mathematics, drawing attention to the fact that although economics is a social science, mathematics plays an important role in understanding economic processes. Due to the complexity of human behavior, it isn't easy to achieve mathematical precision in economics. However, thanks to mathematical tools such as econometrics and modeling, it is possible to plan, predict, and analyze the relationships between economic variables. Therefore, using of mathematics in economics is necessary. It is stated that correlations should be understood in understanding the relationships between economic activities and the extent of the relationships. The development of regression models is emphasized in predicting future trends and supporting decision-making processes. However, the difficulties economists face when using advanced mathematical techniques are mentioned. Despite some of the difficulties, risk, and uncertainty conditions mentioned, it is emphasized that mathematical or econometric analyses continue to be important for planning and making consistent estimates and that some conveniences have been experienced with technological developments. As a result, it is stated that a balanced approach is needed in using mathematical tools in economics. In other words, it is stated that models, which are merely tools rather than goals for economic analysis, have limitations and that it is desired to benefit from the prediction and consistency of these tools. Additionally, it is suggested that future education should both update and follow the analysis tools offered by technology and place more emphasis on mathematical and econometric knowledge to develop the ability to better predict uncertainties.

Key Words: Economics, Econometrics, Human Behavior, Mathematical Modeling, Predictive Modeling

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1. Introduction

Economics is an important branch of science that uses mathematical tools to examine social issues. As it is known, economics is a social science that fundamentally studies human behavior. However, understanding these processes is difficult, as in every social science. Because the subjects that economics studies are based on human behavior, expectations, and decision-making processes, they cannot always give definitive results. People's behaviors are not the same. They can be unpredictable, complex, and even irrational. Due to these situations, as in all social sciences, economics is not a fully predictable and controllable structure.

Economics, a part of social sciences, must use mathematical models to understand and predict these uncertain and variable elements while examining human behavior, preferences, and economic decision-making processes. However, the complexity and unpredictability of human behavior create difficulties in terms of mathematical precision and validity of models. In this context, those who deal with economics accept that it is difficult to make plans and predictions without having econometric knowledge, while at the same time questioning the extent to which these mathematical tools are suitable for the nature of social sciences. In this study, it was tried to briefly examine how a balance can be established between the necessity of mathematical modeling in the economy and the complexity of human behaviors to achieve real results and the developments in this direction.

2. The Nature of Economics

Economics as a Social Science

Economics is generally defined as "a discipline that investigates how people balance their unlimited needs with limited resources and tries to understand economic decision-making processes" (Hayes, 2024). Therefore, the economic preferences of individuals, companies, and societies and the factors that affect these preferences are analyzed by economics. The factors that affect these preferences and the ways they are affected are quite complex and variable. Even these factors can sometimes be irrational. It is seen that psychological, sociocultural, and environmental factors are generally effective in people's decisions (The Impact of the Macroeconomic Environment on Social Preferences, 2023). This makes it difficult to determine the results of economics in advance and reduces the chances of success in planning processes. For example, it is seen that the consumer, as one of the basic economic units, does not only consider the price when purchasing a product; it is affected by past experiences, personal tastes, and social trends. Therefore, those who deal with economics have to deal with the uncertainty of economic processes while trying to solve this complex structure of human behavior (DeMartino, Grabel, & Scoones, 2024).

Mathematical Precision and Human Behavior

Mathematics is a discipline that seeks precision and consistency. However, since economics studies human behavior, it cannot always provide this precision. The complexity and unpredictability of human behavior create difficulties in terms of mathematical precision and validity of models (Kenton, 2024). Although many economic theories are based on mathematical models under simplified assumptions, the complexity of human behavior in real life can limit the validity of these models (Visser, 2020). For example, one of the important factors for demand analysis is knowing consumer demand. However, it is often impossible to predict exactly when and under what conditions a consumer will buy a product. Because this decision may vary and change depending on personal preferences, psychological factors, and environmental conditions. Therefore, the search for mathematical precision in economics is limited due to the unpredictability of human behavior (Ouliaris, 2011).

3. Relationship Between Mathematics and Economics

The Role of Mathematics

As is known, one of the important scientific fields of study where social science meets mathematical tools is economics. Those working in this field use mathematical models and econometric methods to understand the relationships between economic events and to predict the relevant trends and changes. Analyses made with mathematical methods simplify the complex economic processes of real life and make these processes easier to understand. Mathematical methods are used especially in microeconomic analyses, optimization techniques, and balance models. Similarly, in macroeconomic analyses, mathematical models are used to make inferences on issues concerning the general state of the economy. All these show that mathematical tools are the basic instruments of economics (Mokhov, Aliukov, Alabugin, & Osintsev, 2023).

Econometric Models and Correlations

A model in everyday use is a simplified representation of a real-world process. Similarly, econometric models are important mathematical tools used to examine relationships between current economic data and make future predictions. These models are generally based on economic theories that assume the optimization of the behavior of economic actors. It attempts to conclude economic data using statistical inference techniques. It reveals the interactions between economic variables through correlations. Similarly, it attempts to predict future economic conditions by performing regression analyses based on past data.

4. Challenges and Contradictions

Mathematical Challenges for Economists

The use of mathematics in economics gained indisputable importance after World War II. Although it was first used in General Equilibrium Theory, it continued to be used in fields such as econometrics, linear programming, input-output analysis, and game theory (KANOPI FEB UI, 2021). However, the fact that economic explanations have almost become secondary due to the increasing importance of mathematics has caused questions to arise in people's minds. The fact that mathematics has lost its feature of being a tool in understanding economic problems and seeking solutions, and has even become a goal, has increased these reactions. The fact that economic issues have begun to be explained with models created with restrictive assumptions and that the primary purpose of these mathematical models is to ensure the internal consistency of the model rather than explaining the economic phenomenon itself has justified these reactions. Mathematics and logic can undoubtedly be applied to every field. However, it would not be right to try to reduce the essence of the matter to mathematical relationships.

Another reaction to the use of mathematical tools comes from those working in this field. It is difficult for economists, who are generally educated in social sciences and specialized in this field, to perform advanced mathematical and statistical analyses. Although they are more successful in theoretical studies aimed at understanding human behavior, dealing with mathematical analyses and numerical data will require additional training. This training is especially necessary in econometric modeling and the analysis of large data sets. With the Neoclassical Economic approach becoming the mainstream understanding, the dominance of modern mathematical economics continues. It is still necessary to know advanced mathematics such as derivatives, integrals, matrices, determinants, and differential equations. Economists must combine their knowledge of social sciences and mathematical methods to meet mathematical challenges. Mathematical economics and econometric modeling are also included in university curriculums, due to the predominance of neoclassical economics.

Theoretical Models and Real-Life

While mathematical models used in economic analysis provide important tools for understanding complex economic processes, they can sometimes lead to misleading simplifications. The analyses performed and the results obtained cannot adequately reflect the complexity of the real world. The assumptions on which the models or the theories they attempt to reflect are based do not conform to real life and remain abstract (Ouliaris, 2011). Whereas, the purpose of establishing these models and theories is to explain economic events by simplifying, classifying, and generalizing them. If the results they reach do not conform to real life, neither the theory nor the model has any importance. Those who perform this analysis must be aware of the limitations of mathematical models and constantly question the extent to which these models represent the real world. The fact that the assumptions of the dominant neoclassical theory are far from real life is a

prominent part of these criticisms. The rationality of people and the decisions they make (rationality assumption, homo economicus idea), decision-making the perfect competition system as an example (prevalence of competition assumption), taking margins into account in decisions (marginality assumption), benefit maximization and cost minimization (maximization assumption) are not always possible (Kenton, 2024).

5. The Necessity of Econometric Analysis

Future Forecasts and Planning

As mentioned, mathematical tools are vital for economic planning and future predictions. Those who perform economic analysis try to predict future economic events using information obtained from past data. They use econometric models for this purpose. Thanks to econometric analysis, it becomes easier to understand economic data and determine the relationships between data, and the decisions taken are supported by these results. Thanks to econometric analysis, more conscious and strategic decisions can be made. The predictions made through these analyses are important in shaping the strategic decisions of policymakers, companies, and investors. For these reasons, mathematical predictions and econometric analysis have become one of the cornerstones of economic planning (Ayangbah, 2024).

Uncertainty and Risk

Economic processes generally contain uncertainties. Political instabilities, changes in government policies, natural-climate disasters, and market fluctuations cause this. As a result, it becomes difficult to predict the future economic environment and risks or uncertainties increase in some areas. In this environment of uncertainty, it becomes challenging to make decisions, make investments, and have correct expectations (Mohades, 2024). Although mathematical models account for these uncertainties and risks, the chance of success decreases. Because these models cannot accurately predict all possibilities. For example, models used to analyze risks in financial markets generally work under certain assumptions. It is not always possible for these assumptions to reflect reality.

However, even if not complete, probability estimates are given for the variables of interest thanks to the models. In this way, some of the uncertainty about the state of the economy is captured. Policymakers try to make the best choices by determining which policy option has the greatest expected benefit according to these probabilities. Therefore, mathematical modeling makes it possible to understand risks and uncertainties better.

6. Solutions and Suggestions

Correct Use of Mathematics in Economics

Economic processes can be better understood by using the tools provided by mathematics correctly. Of course, it is important to be aware of the limits of the capabilities of these tools and the complexity of human behavior. It should not be forgotten that mathematical models are valid under assumptions since models operate under certain assumptions. In addition, their simplification of complex realities, their inability to account for unexpected events, their dependence on accurate data, and even their potential for misuse also requires additional caution. It should not be forgotten that economic models are only as good as the data they are based on. In addition, it should not be forgotten that these assumptions do not always fully reflect the real world. If the data used is incorrect or incomplete, the model's predictions will of course be incorrect. This is a significant problem, especially in developing countries where reliable data is difficult to find. Those who want to benefit from economic models should also keep in mind that human behavior is not fully predictable (Syll, 2018).

Education and Research Needs

With the developments in technology and financial transactions, economic analyses require more detailed information and more extensive operations. Similarly, economic models are rapidly developing and changing in line with changing social, economic, and political realities. Economic models are constantly being enriched and improved with the use of new research approaches and the discovery of Artificial Intelligence applications (Craddock, 2024). For example, it is not easy to explain in detail the complex economic problems that affect different social groups in different historical periods and different geographical areas. However, with the help of Artificial Intelligence, powerful analytical tools can be created and such problems can be analyzed by adapting a technique, method, and research approach from different disciplines such as Artificial Neural Networks, big data, machine learning, data science, and iconography.

One of the main advantages of AI-based analysis is its ability to handle nonlinear relationships and complex interactions between variables. Traditional econometric models are generally based on linear relationships and struggle with very complex, interconnected economic systems. However, machine learning algorithms, especially deep learning models, can capture these complex relationships more effectively and potentially lead to more accurate predictions. Thanks to these algorithms, a much wider range of data can be processed than traditional economic models, including structured data such as economic indicators and financial market data, as well as unstructured data such as news articles, social media posts, and satellite images (Craddock, 2024). Accordingly, it is thought that in the future, it will be more important for those who want to do economic analysis to be taught sufficient technology use (prompt engineers) in addition to sufficient mathematical and econometric knowledge.

Conclusion

Economics, which includes the complexity of social sciences, is trying to become more understandable and more easily accepted with the help of mathematical precision. Mathematics has become an indispensable tool for understanding, modeling, and predicting economic events. The speed and form of use have developed rapidly towards the present day. Although this speed is sometimes criticized with the claims that the use of mathematics has ceased to be a tool and turned into a goal, it is a fact that the use of mathematics in analyses is beneficial.

Especially with technological developments and apps such as AI, the use of mathematics and models has become easier, and methods that even those who do not have sufficient knowledge of mathematics and econometrics can use have begun to be offered. AI-supported predictive analyses have made it easier to make more detailed and frequent economic estimates. While previous estimates could be updated once every three months or once a month, artificial intelligence systems can provide updates close to real-time. In addition, the use of alternative data sources has increased. Credit card transactions, mobile phone usage patterns, and satellite images of various transactions have virtually eliminated significant reporting delays.

While these developments are taking place, factors such as unpredictability in human behavior, extraordinary developments, and unexpected political interventions are pushing the limits of these analysis models and methods and making it difficult to obtain definitive results. Therefore, while using the benefits of mathematical tools, the limits of these tools should also be taken into consideration and approaches appropriate to the complexity of human behavior should be developed. Although mathematics and new algorithmic approaches provide valuable contributions to economics, these disciplines need to be brought together in a balanced manner. These disciplines and the ways they are compatible with each other need to be addressed with adequate content in the curricula of educational institutions.

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