УДК 331.53
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MODERN MATHEMATICAL ECONOMICS

From the later-1930s, an array of new mathematical tools in a way similar to new mathematical methods earlier applied to physics. The process was later described as moving from mechanics to axiomatics. These methods are: differential calculus, game theory, agent-based computational economics and others. Formal economic modeling began in the 19th century with the use of differential calculus to represent and explain economic behavior, such as utility maximization, an early economic application of mathematical optimization. Some scientists (Vilfredo Pareto, Paul Samuelson) applied mathematical concepts from physics to economic problems

and lead to fundamental premise of mathematical economics. Pareto's statement was the first formal assertion of what would be known as the first fundamental theorem of welfare economics. These models lacked the inequalities of the next generation of mathematical economics. Samuelson approached the problems of applying individual utility maximization over aggregate groups with comparative statics.

This and other methods provided the foundation for mathematical economics in the 20th century. Also it is worth mentioning such models and theories as linear and input - output economics models, mathematical optimization, linear optimization, nonlinear programming, functional analysis and differential decline and rise theory that had a great influence on the development of mathematical economics.

In 1936, economist Wassillie Leontief built his model of input-output analysis from the 'material balance' tables constructed by Soviet economists. With his model, Leontief described how changes in demand in one economic sector would influence production in another. He estimated the coefficients of his simple models, to address economically interesting questions. In production economics, "Leontief technologies" produce outputs using constant proportions of inputs, regardless of the price of inputs, reducing the value of Leontief models for understanding economies but allowing their parameters to be estimated relatively easily. In contrast, the von Neumann model of an expanding economy allows for choice of techniques, but the coefficients must be estimated for each technology.

John von Neumann, working with Oskar Morgenstern on the theory of games, broke new mathematical ground in 1944 by extending functional analytic methods related to convex sets and topological fixed-point theory to economic analysis. Their work thereby avoided the traditional differential calculus, for which the maximum–operator did not apply to non-differentiable functions. Continuing von Neumann's work in cooperative game theory, game theorists Lloyd S. Shapley, Martin Shubik, Hervé Moulin, Nimrod Megiddo, Bezalel Peleg influenced economic research in politics and economics.

Agent-based computational economics (ACE) studies economic processes, including whole economies, as dynamic systems of interacting agents over time. In corresponding agent-based models, agents are not real people but "computational objects modeled as interacting according to rules" ... "whose micro-level interactions create emergent patterns" in space and time. The rules are formulated to predict behavior and social interactions based on incentives and information. ACE models apply numerical methods of analysis to computer-based simulations of complex dynamic problems. It has a similarity to, and overlap with, game theory as an agent-based method for modeling social interactions.

Some economists state that mathematical economics deserves support just like other forms of mathematics. Mathematical economics and other mathematical sciences have a history in which theoretical advances have regularly contributed to the reform of the more applied branches of economics. Following the program of John

von Neumann, game theory now provides the foundations for describing much of applied economics. In the last decade, with the rise of the internet, mathematical economists and optimization experts and computer scientists have worked on problems of pricing for on-line services.