

# A Critical Review of Mises on Mathematical Economics

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The *a priori* sciences -- logic, mathematics, and praxeology -- aim at a knowledge unconditionally valid for all beings endowed with the logical structure of the mind. (Mises)<sup>1</sup>

Mathematical economics is not a distinct branch of economics. . . Rather, it is an *approach* to economic analysis. . . Mathematical economics should not and does not differ from the *non*mathematical approach to economic analysis in any fundamental way. (Chiang)<sup>2</sup>

## I. Introduction

This essay presents a critical review of Mises' treatment of mathematical economics. Its focus is rather narrow in as much as the argument deals neither with the broader issues surrounding Austrian methodology, about which Mises has written so penetratingly, nor with the contemporary (Austrian and non-Austrian) critique of the use of mathematics to derive economic theory. Furthermore, like Mises, I maintain the distinction between mathematical economics, on the one hand, and statistical analysis (econometrics), on the other, and deal primarily with the former. Finally, the focus is on Mises' thought rather than on that of his former students and contemporary Austrian economists. While Austrian economics has a dynamic and evolving research program, Mises is acknowledged to have laid down the methodological foundations of modern Austrian thought.

It may be useful to elaborate briefly on the distinction between mathematical economics and econometrics; especially, because the former is the proper subject of this essay, while the latter is given only tangential treatment and then only in an effort to clarify several of Mises' points. Mathematical economics utilizes mathematics to derive economic theorems from well specified sets of axioms, postulates, and assumptions. In any given derivation, the steps of deductive reasoning employ mathematical theorems. By contrast, econometrics is the

application of statistical theory to the problems of data sampling, estimation, and hypothesis testing. The goal of mathematical economics is the generation of economic theorems. The function of econometrics is to analyze an array of data to determine if there exists a systematic underlying structure.

The paper is organized as follows. Section II outlines the method of praxeology. Section III presents the Misesian case against mathematical economics. It concludes that while some of his arguments are misplaced and others less compelling than conventionally thought, Mises nevertheless does make an original and valuable contribution to our understanding of the limitations of mathematical economics. Section IV argues that the mathematical derivation of economic theorems satisfies the major methodological tenets of praxeology. Moreover, it maintains that non-obvious implications of a theory are more likely to emerge using mathematics than when using the preferred approach of the praxeologist, namely, chains of verbal logic. Section V concludes that the strict Misesian praxeological approach is unnecessarily confining and leads to a particular 'style of theorizing'.

## II. The Method Of Praxeology

In his three works, *Human Action*, *The Ultimate Foundations of Economics*, and *Epistemological Problems in Economics*,<sup>3</sup> Mises not only constructs the method of praxeology, he attacks the foundations of alternative methodologies, including those of historicism, institutionalism, and mathematical economics. Mises' intent is not only to offer a modern Austrian School framework for economic analysis, but to demonstrate its scientific superiority to alternative historic/descriptive based paradigm by destroying their philosophic underpinnings. Before considering the Misesian case against mathematical economics, this section outlines the structure of praxeology.

The fundamental touchstone of praxeology is the axiom of human action. It is an axiom because each person recognizes the concept of human action as self-evident, i.e., the category of action is logically prior to experience. As Mises writes, "All the concepts and theorems of praxeology are implied in the category of human action".<sup>4</sup> When the fundamental axiom is combined with auxiliary axioms -- acting takes time, preferences among individuals differ, and the future is uncertain, for example, -- the whole corpus of Austrian economic theory can be deduced. Praxeology is purely deductive and formal. Consider the following example of praxeological reasoning offered by Rothbard:

Action implies that the individual's behavior is purposive, in short, that it is directed toward goals. Furthermore, the fact of his action implies that he has consciously chosen certain means to reach his goals. Since he wishes to attain these goals, they must be valuable to him; accordingly he must have values that govern his choices action takes place in time and is directed toward the future.... The fact that people act necessarily means that the means employed are scarce in relation to the desired ends.<sup>5</sup>

Such verbal chains of reasoning generate economic theory. Because the axioms are self-evident, the logically derived theorems and implications of praxeology are known to be true with apodictic certainty. "The theorems attained by correct

praxeological reasoning are perfectly certain and incontestable, like the correct theorems of mathematics," observes Mises.<sup>6</sup> Moreover, they can be neither confirmed nor contradicted by experience. Only the epistemological status of the axioms and the deductive logic leading to a theorem can be questioned or examined for error. The theorems need not and, indeed, cannot be tested with empirical evidence.

While the science of human action is built up from an understanding of the actions of the individual, praxeology is not concerned with the particular or accidental circumstances surrounding an act, but only with the essential elements of choice. The theorems of praxeology are thus universal across time, place, and persons.

Mises contends that the status of the action axiom is established as *a priori* because it is part of "the essential and necessary character of the logical structure of the human mind."<sup>7</sup> By contrast, Rothbard argues, ". . . that the fundamental axiom and subsidiary axioms are derived from the experience of reality and are therefore in the broadest sense empirical."<sup>8</sup> Going somewhat further, Rizzo maintains that the action axiom is both *a priori* and empirical:

That man acts is logically prior to any concrete manifestation of action. . . one must have the concept of action before one can even recognize action in the so called real world. . . History as a complex of human behavior, is analyzed and interpreted by the use of praxeological theorems which are, in turn, derived from relatively simple experience.

[Furthermore] praxeology as applied to history does not depend merely on deductions from the action axiom. It requires subsidiary assumptions derived empirically to delimit the scope of the praxeological system. To increase the quantitative definiteness of relationships in applied praxeology (economic history), we require increasing specificity of the subsidiary assumptions. These assumptions must become both more numerous and more precise. This of course results in conclusions which are no longer apodictically certain.<sup>9</sup>

For Mises experience provides a context for analysis; it directs the attention of the analyst to interesting problems. Praxeology is not mere mental gymnastics. For example, we could think about a world where labor did not occasion disutility, but though the theorems we derive about such states may be logically valid, they are not interesting.<sup>10</sup> Mises insists that the theorems of praxeology are both certain and illuminating of reality, just as the theorems of Euclidean geometry are logical and a means for interpreting the world around us.

I am now in a position to summarize the signature characteristics of praxeology to which I will return later when discussing the methods of mathematical economics: i) Praxeology is axiomatic. Its theorems are deduced from a small set of self-evident axioms (or the action axiom plus subsidiary axioms based on, widely accepted, simple empirical observation). ii) It is grounded in methodological individualism. Because the foundation of praxeology is the action axiom and only individuals evaluate, plan, and act, theory must be built up from an understanding of the essence of human action. Nevertheless, the ultimate goal of praxeology is to

comprehend the development, evolution, and decline of social institutions such as markets, governments, the legal system, religious communities, and political parties.<sup>11</sup> The contours of the social order are the proper focus of praxeology. iii) Praxeology is not about goods and services, it is about perceptions and valuations; hence it is based on subjectivism. iv) Praxeology rules out comparing the valuations of different individuals. v) Its theorems are universal across time, people, and places. And vi) praxeology is value free. It cannot serve as the basis for making judgments about whether an action is good or bad, fair or unfair.

What must strike many readers is that this is a familiar list of methodological tenets. Precepts that are fully in accord with the way the qualitative conclusions of neoclassical mathematical economics are derived. However, the discussion of this accord is postponed until Section IV, after the Misesian case against mathematical economics is outlined in the next section.

### III. The Misesian Case Against Mathematical Economics

This section explores only a subset of the methodological issues raised by Austrian economics, namely, the Misesian critique of mathematical economics. Mises' most devastating attack on mathematical economics is contained in a few pages of *Human Action* (pp.350-357 and 377-379). Mises maintains that:

the antagonism between the logical and the mathematical economists . . . is not a dispute about heuristic questions, but a controversy concerning the foundations of economics. . . The mathematical method must be rejected not only on account of its barrenness. It is an entirely vicious method, starting from false assumptions and leading to fallacious inferences.<sup>12</sup>

Mises begins by distinguishing three groups of mathematical economists (my terminology): (A) the statisticians, (B) that group of mathematical economists studying the relationship of prices to costs, and (C) the algebraists, who express economic ideas using symbols and equations.

A) Mises argues persuasively that statistical analysis can never be a source of economic theory. Theory is prior to the gathering and analysis of data. Facts do not speak for themselves. And even if we agree with Rothbard that the axioms of praxeology are "broadly empirical", that does not contradict Mises. Clearly Mises has in mind the formal application of statistical techniques to the analysis of data, not merely observation of the reality around us. Nor would present-day econometricians disagree. The work of econometricians, as they interpret it, is to test the hypotheses of economic theory, not to generate the theories themselves. Although in characterizing Tinbergen's econometric work, Mary S. Morgan observes, "As is clear from this example, the formation of each individual equation and the particular choice of variables were found by iterating between theoretical ideas and empirical investigations."<sup>13</sup> Here Morgan describes the interaction between a priori theorizing and estimating statistical models, with the empirical work being interpreted as useful in refining theory. Nonetheless, when Mises refers to the Econometrics Society as being based on the belief that 'science is measurement', he exaggerates. No less a figure in the Society than T. Koopmans

wrote an influential essay, in 1947, entitled "Measurement Without Theory," in which he questions the validity of empirical work without a prior theoretical foundation.<sup>14</sup>

In addition, Mises argues that there are no constants in economic relationships that can be estimated with statistical techniques. The significance of this observation should not be overstated, however. No econometrician seriously argues that there are economic constants, analogous to those in nature such as Planck's Constant, that can be statistically estimated. Nor would the econometrician argue, for example, that the price elasticities estimated for a particular commodity remain constant across markets and over time. Indeed, much applied econometrics seeks only to estimate the sign and statistical significance of coefficients associated with economic variables. Interest is focused on the predicted direction of economic effects, not their magnitudes.

With few exceptions, economic theory holds no implication for the magnitude of an effect; the theory merely implies that, for a variety of markets and time periods, the economic effect of an exogenous change always operates in the same direction. However, in some cases, a theory may imply upper and/or lower bounds on magnitudes. The estimation of the algebraic sign of an economic effect, particularly when modestly interpreted as merely being a finding consistent with theory, does not seem to violate Mises' methodological stricture.

Moreover, even those statisticians interested in magnitudes do not claim exactitude. Their work, that of estimating plausible ranges of values, does not proceed on the assumption that complex economic phenomena are made up of behavioral constants and fixed relationships. Beyond the direction of an effect, statistical estimates may provide additional information about the relative importance of different effects, as gauged by their relative magnitudes. Finally, econometricians can estimate models with time varying parameters. These models are designed around precisely the Misesian idea that behavioral coefficients can change over time.

This is not to deny that some applied econometricians do place weighty interpretations on their estimates, breathing exaggerated significance into statistics. They mistakenly claim that economics is a predictive science and that they can offer meaningful forecasts of economic events. Yet even here the fault lies with the practitioner and not with statistical analysis.

Mises also argues emphatically that statistics cannot be used to test economic theorems. Theorems are the logical deductions of the self-evident axioms and, therefore, barring logical error, are certain and cannot be confirmed or rejected with statistics. The complexity surrounding the concrete events that constitute economic history; the unique concatenation of factors entering into human choice in a particular time and place, and the absence of constants in the relationships governing human action imply, for Mises, that historical data can never be used to test the universal theorems of economic science.

Furthermore, he argues, the reality of human circumstances is that there are a multitude of factors influencing any given decision. This, Mises asserts, implies that we can never observe how a change in a single factor influences an economic

choice. In other words, the analyst cannot capture all the relevant factors, but one, in the *ceteris paribus* pound. Yet this latter argument underestimates the ability of econometricians: One, to construct multiple regression models that take into account any number of factors that simultaneously influence economic behavior and, two, to design multiple equation models that permit the analysis of a complex phenomenon wherein a number of choices are being made simultaneously. The guiding principle is mutual interdependence not singular, unidirectional cause and effect.

B) The second group of mathematical economists criticized by Mises are those who explain market price in terms of 'real' costs, while ignoring market processes and money. Real costs are determined by some measure of physical inputs. Costs are thus expressed in observable, material terms not value terms. Although Mises does not cite specific works, presumably he has in mind the material balance, input/output models of Leontief and the theories of objective value of Marxists and Neo-Ricardians. Mises' argument need not detain us here, because his position on the ultimate subjectivity of costs and the necessity of reckoning costs and prices in money terms has been vindicated.

C) The last of the three groups of mathematical economists, criticized by Mises, is recognizable today as those scholars who employ mathematics to develop economic theory. Indeed, that is what mathematical economics has come to mean. In Mises' terms, "... they are openly and consciously intent on solving catallactic problems...."<sup>15</sup> I turn first to a series of minor criticisms, which stem, I believe, from a misunderstanding of the mathematical method. I then deal with several more significant Misesian criticisms that mathematical economists largely have ignored.

Mises insists that mathematics adds nothing to the description of the economic phenomenon being studied. "The deliberations which result in the formulation of an equation are necessarily of a nonmathematical character. The formulation of the equation is the consummation of our knowledge; it does not directly enlarge our knowledge."<sup>16</sup> The point is obviously correct, but I do not understand why it is a criticism of mathematical economics. The subject matter is economics; the engine of analysis is mathematics. The twin features of mathematical economics are distinct. But precisely the same thing can be said about praxeology — the rules of logic have no content. They are not part of the description of an economic problem.

Rothbard's related point is that the mathematical steps in the derivation of an economic theorem have no economic meaning themselves, as do the chains of verbal logic employed by the Austrians.<sup>17</sup> In most cases that simply is not correct; each step in a mathematical derivation can be given an economic interpretation. But even if Rothbard is correct, the ultimate purpose of the use of verbal logic or mathematics is the derivation of meaningful economic theorems. Both approaches accomplish that. Additionally, as I argue more fully later, mathematical formulations offer several advantages, over verbal logic, in theory development.

Because the mathematical treatment of economics relies on a mechanical analog borrowed from physics, it is a fallacious approach to the study of purposive human action asserts Mises. It fails because there are no constants or constant relations between economic elements.<sup>18</sup> The problem with this criticism is that

mathematical formulations need not be based on constants and typically those employed by mathematical economists are not. Mises fails to make the distinction between explicit functions, those used to formulate the 'laws of physics' and implicit functions, the class more typically used by economists. The former may be used by economists for heuristic purposes, but not for the development of economic theory. There is neither justification nor necessity for using explicit functions in the derivation of economic theory. In any given analysis, background economic knowledge, not mathematics, suggests which factors to include and how each is related to the other significant factors in the model. Here the relations among variables are strictly qualitative, i.e., the relationships are not assumed to be constant. In spite of the qualitative nature of the formulation, quite interesting theorems can be derived.

Again Rothbard makes a related point. When employing calculus and the maximization hypothesis, mathematical economists assume that economic relationships are continuous so that derivatives can be taken. (His observation applies equally to explicit and implicit functions of the type discussed above.) But, as Rothbard correctly observes, economic relations are often discrete and can involve inequalities, upper or lower bounds, thresholds, and other discontinuities, which rule out the use of calculus. Unfortunately for this criticism, all the major theorems of neoclassical economics can be derived using set theory which does not in any way depend on the continuity assumption. Indeed, the derivations of economic theorems, using set theory, are often shorter and more elegant than those employing the calculus.

"Valuing that results in action always means preferring and setting aside; it never means equivalence or indifference", writes Mises as another point in his attack on mathematical economics.<sup>19</sup> Here Mises refers to the theory of consumer behavior developed in the 1930s by R. G. D. Allen and Sir John Hicks. Their theory is presented graphically and at its core is the concept of indifference. This concept allows for the construction of a set of bundles, differing only in the combination of goods making up each bundle, such that the bundles are equivalent in the mind of the person asked to evaluate them. Logically such bundles must exist. We have only to ask a person to choose between two or more bundles and then adjust the composition of each until the person says the bundles are equivalent, i.e., she is indifferent as among the bundles. Hence, the criticism cannot be a matter of logic.

An indifference curve, on a two dimensional graph where goods X and Y are measured on the axes, is simply a boundary between bundles of goods X and Y which are preferred and those that are inferior to a particular set of bundles. An indifference curve comes into play only in defining an equilibrium, after the consumer has chosen. It is true that the concept of indifference is about evaluations, not the act of evaluating. But indifference is not inconsistent with the process of evaluating, grading, and choosing; indeed, it is the culmination of that process. Expressing consumer equilibrium as an equality between the marginal rate of substitution of the goods (the slope of the indifference curve) and the ratio of the prices of the goods is a logical implication of the concept of "making decisions at the margin", certainly a notion congenial to Mises.

Economic theory is abstract and analytic not descriptive. The concept of indifference is a logical construct designed to further the elucidation of consumer behavior. The justification of an economic concept depends on its usefulness in deriving fruitful theorems about economic behavior. In general, a concept is replaced in a theoretical argument if it is not useful or when a more powerful concept is developed. In this case, the indifference curve, used for the graphic presentation of consumer theory, has been replaced, because geometric analysis largely has been replaced by higher mathematics.

The above criticisms of mathematical economics are not telling because, for the most part, they are based on an inaccurate and incomplete understanding of mathematics. At most, they are criticisms of the practices of some economists, but do not in any way constitute a fundamental attack on the application of mathematics to economic theorizing.

Mises does offer significant criticism for which mathematical economists as yet offer no satisfactory answer. For Mises the principal deficiency of mathematical economics is that it ignores the market process. Here, his argument is stronger. The hard core of modern mathematical economics is constrained optimization. Mathematical analysis begins with the assumption that individuals optimize; it then proceeds by using mathematical theorems to derive the necessary and sufficient conditions that must hold if the individual does optimize. These conditions define an equilibrium choice. When underlying economic factors change, the individual is assumed to reoptimize and a new equilibrium is found. Statements that compare and contrast the original and new equilibria constitute the economic analysis. This is the method of comparative statics (or comparative dynamics depending on the economic nature and the mathematical structure of the analysis). As yet the approach offers no way of describing the underlying market process by which the decisions of an individual move her from one equilibrium position to another.

Mathematical economics provides a powerful statement of the logic of choice, but offers little in the way of an explanation of market processes. Until recently, the processes by which disparate bits of information are coordinated and the consequences of incomplete information, the subjectivity of expectations, uncertainty, and learning-by-doing, for example, have been down played in economic modeling. Absent from mainstream economics were roles for entrepreneurship, middlemen, market makers, arbitragers, and speculators. Indeed, their presence in the marketplace has been interpreted as evidence of inefficiency and monopoly power.

Worse, the abstract first order conditions of competitive equilibrium have been raised to a normative standard by which the market is to be judged. Of course, no real market ever satisfies those static conditions and thus decentralized markets stand condemned, not by actual failures, but by the shortcomings of received economic theory. Advertizing, volume discounting, vertical integration, exclusive dealing, tie-in-sales, and long term contracting have been interpreted as devices employed by firms in search of monopoly power rather than as devices for economizing on production costs, information, and transaction costs; assuring quality service, and coping with uncertainty over market demand and the timely



acquisition of inputs. This has been the fundamental limitation of neoclassical economics fashioned as it is by mathematical modeling. This erroneous theory of market failure stems, at least in part, from the inability of mathematical economics to deal readily with information flows, expectations, learning, and market processes.

Nevertheless, though mathematical economics remains rooted to equilibrium analysis, it remains the case that the economics of uncertainty, information, search, principal/agent problems, property rights, and institutional evolution are being explored mathematically in fruitful ways.<sup>20</sup> Major contributions have been made during the last two decades to our understanding of market and non-market processes by economists, employing mathematical methods, to transaction economics, the new institutional economics, law and economics, and public choice theory.

Moreover, as Mises himself points out, "Both the logical and the mathematical economists assert that human action ultimately aims at the establishment of a state of equilibrium and would reach it if all further changes in the data were to cease."<sup>21</sup> As an example, the evenly rotating economy is an insightful stationary state equilibrium model used by Mises. To argue that because it does not describe an actual economy, it is useless or misleading is to misunderstand the role of theory in the explanation of complex economic phenomena. Both Austrian and mathematical economics make use of the concept of equilibrium. Indeed, one of the great contributions of economics has been to explain the general tendency of market processes to coordinate the decisions of individuals in such a way as to generate a coherent socio-economic order.

#### IV. Mathematics and the Methodological Tenets of Praxeology

The purpose of this section is to demonstrate that the mathematical approach to deriving economic theorems is consistent with the six major methodological tenets of Austrian economics identified earlier and, further, to demonstrate certain advantages, over 'logical economics', in using mathematics to derive economic theory. The method of mathematics in deriving theorems is axiomatic; mathematical models are purely formal and deductive. The theorems are already contained in (logically implied by) the axioms, postulates, and subsidiary assumptions set forth at the beginning of an analysis. In this respect, mathematical economics does not differ from logical economics.

As clear is the fact that neo-classical analysis satisfies the tenet of methodological individualism. The theory seeks to explain the essence of the choices made by an individual. From the individual's demand for X coupled with the demands of other individuals is built the theory of the market demand for X. The whole corpus of neoclassical economic theory is built up from the choices of individuals. Increasingly the contemporary theory of the firm has moved away from the fiction that 'the firm' makes decisions and instead traces pricing, output, and quality decisions to identifiable persons within the firm. The theory now explains internal incentive structures, executive compensation schemes, principal/agent problems, vertical integration, and interfirm contracting.<sup>22</sup> Modern neo-classical

and New Classical macro theory traces its results back to the consumption, labor supply, and investment decisions of individuals.

Furthermore, the choices discussed are based on the consumer's subjective valuations, thus, satisfying the subjectivism of praxeology. No interpersonal utility comparisons are necessary or permitted by the mathematical analysis. The mathematical theory of consumer behavior attempts to capture the essence of choice and so is universal. The theory is independent of historic context as to place, persons, and period. Finally, it cannot serve as a standard for judging the moral or ethical dimensions of choice. These represent the six major methodological tenets identified with praxeology. All are satisfied by the mathematical economics.

## The Advantages of Mathematical Economics

There are a number of advantages in the use of mathematics, compared to the use of verbal logic, to derive economic theorems. One, mathematics offers a far larger stock of theorems that can be used in the derivation of economic theory. Mathematical reasoning provides a powerful means for deducing the implications of a set of initial conditions. Two, the axiomatic method forces the theorist to make precise the ideas underlying her analysis. Moreover, this formal procedure readily exposes implicit assumptions and errors in derivations, thereby increasing the likelihood that both will be scrutinized. Three, because the analysis tends to be more explicit and transparent, mathematics facilitates economy and precision in communication among scholars. Four, mathematical analysis is more likely to generate subtle implications not exposed by chains of verbal logic. For example, the distinction between the substitution and income effects of a price change, has clarified a number of economic issues, and is a distinction unlikely to emerge from the application of even a rigorous chain of verbal logic.

Five, using mathematics makes it much easier: i) to determine the sensitivity of a conclusion to the use of an assumption; ii) to compare and contrast alternative theories of the same phenomenon in an effort to determine whether the theories are in fact different; iii) to discover that a theory may in fact explain apparently different phenomena, and iv) to choose among competing theories.

Six, the step-by-step mathematical derivation of a theory suggests both a host of additional new questions and a framework for analyzing them. For example, in the standard model of consumer behavior income is a datum. But it is easy to transform the model to make income a choice variable; to add many more goods, including savings, to the model and to take into account that the consumer is engaging in multi-period planning. The model could be further modified to take into account uncertainty.

The point is that a simple mathematical model naturally generates additional models of increasing complexity. A family of related models is developed easily. The choice among models depends on the questions to be answered. Answers to relatively easy questions may be provided by a simple model; more complex questions may require more sophisticated models incorporating additional choice variables and less restrictive assumptions. Furthermore, much can be learned by

comparing and contrasting the implications of different models within a family, as well as across families of differing theoretical content.

## V. Conclusion

The thesis of this essay is that there is no major methodological gulf between praxeology and neo-classical mathematical economics. While the form and style of theorizing differ in the two approaches, both share axiomatic underpinnings and both embrace methodological individualism and subjectivism. The common ground is far more significant than are the differences.

This is hardly a novel thesis, however. John Stuart Mill places political economy with logic and mathematics as disciplines for which the appropriate method is that of the *a priori*.<sup>23</sup> In an essay reinterpreting Misesian apriorism, Lavoie refers to the traditional view as Euclidean praxeology and with good reason.<sup>24</sup> Mises says as much himself when he observes that, "It would be conceivable to draw up a formal praxeological system patterned after the science of logic or the science built upon the axioms of, for example, Hilbertian geometry."<sup>25</sup> The foundation of praxeology and mathematical economics is the method *a priori*.

The differences that remain are two. The first is the apparent inability of mathematical economists to model the market process in a meaningful way. While this is a significant limitation, it seems likely, for the reasons given in Section III, that mathematical economists will devote more of their attention to the real economic problems involving coordination, learning, innovation, and uncertainty. Genuine dynamic analysis may be in its infancy, but it is developing. As important, economists are beginning to understand that there is much more to economic theorizing than the mathematical elaboration of equilibrium. This growing understanding in turn stems from an appreciation that the central questions of economics are about the consequences of purposive human action for the unfolding of market processes, and not the more narrowly conceived problem of the optimal allocation of resources.

The fact that mathematical economists, perhaps predictably, have dealt with uncertainty by modifying models of perfect information into models of expected utility, with their incumbent limitations and inconsistencies, is not a criticism about the inherent inability of mathematics to provide more powerful models of human behavior. Indeed, that future knowledge by definition is unknown and awaits discovery is as much a problem for praxeology as for mathematical economics. That Austrian economists have stressed the problem of genuine uncertainty and subjective expectations is not the same as providing an explanation. Uncertainty remains a conundrum for both approaches.<sup>26</sup>

The second remaining difference between praxeology and mathematical economics is in the style of theorizing. The praxeologist almost invariably returns to first principles when undertaking a new work. As a consequence, Austrians tend to write relatively more books and monographs than scholarly articles. Their works tend to deal with very fundamental concepts -- the ultimate determinants of interest rates, time, entrepreneurship, expectations, valuation, and methodology. By contrast with the mainstream, the articles of the praxeologist are heavily slanted

toward history of economic thought and methodology, rather than applied analysis or specific policy issues. When dealing with public policy issues, the Austrians seem to follow Buchanan's prescription to apply broad, general principles.<sup>27</sup> Examples might include emphasizing the efficacy of decentralized markets and the long run advantages of free trade. The method of praxeology leads economists to be generalists, studying and making use of the whole of economic theory. Austrians rarely specialize. Turning to normative analysis, the Austrian economist is more likely to issue a broad brush condemnation of 'the welfare state' than an analysis of a specific program coupled with suggestions for reform.

There are, of course, important exceptions to the above characterization. An obvious contemporary exception is the contribution Austrian economists are making to the analysis of the transition of the economies of the former Soviet Union and eastern Europe. This transition toward a market economy raises very fundamental issues and thus plays to the strength of Austrian Economics. Conventional economists seem to have less of a grasp of the underlying institutional arrangements and cultural attitudes necessary before markets can appear and flourish.<sup>28</sup>

I am the first to applaud the profound discussion of the fundamental elements of economic theory by the Austrians. It is quite simply an intellectual feast to reread *Human Action* and to savor the breathtaking sweep of Mises' analysis. All the fundamentals are in Mises' *magnum opus*. Much that goes for economics today seems intellectually puny by comparison. Therefore this characterization of praxeology or Austrian economics is not to be interpreted simply as a criticism. Rather, I am suggesting that there exists among praxeologists a tendency to exhibit a characteristic style that I believe stems from and is constrained by their insistence on the use of chains of verbal logic.

In contrast to the lengthy literary analyses of the praxeologist, often going back as they do to a reiteration of first principles, the mathematical economist normally offers a compact, analytically rigorous framework, quickly comprehended by fellow scholars. The rigor and economy of communication seems a virtue of the mathematical method. Using mathematical techniques allows the scholar to cut into an economic problem with a minimum review of background principles. Complex analyses can be telescoped without sacrificing rigor and, because the assumptions and steps of a derivation are explicit, the complete argument is laid bare making it easier to comprehend and criticize.

In addition, mathematics offers great flexibility in generating new models. The objective function and the content and number of constraints in a model can be modified easily. The twin advantages are that models can be tailored to the specifics of new economic problems, without the necessity of starting from ground zero, and anyone familiar with the original model can quickly grasp the point of the new analysis. Mathematical economists are careful to distinguish between the choice variables of the individual (the variables endogenous to the analysis) and the environmental variables over which the individual exercises no direct control (the exogenous variables). This too promotes clarity.

The complaint that mathematical economics is nothing more than a series of *ad hoc* models, while sound economic theory is of a whole cloth, misses the point.

Neoclassical economics, expressed mathematically, possesses a well-defined theoretical center, i.e., a Lakatosian hard core, of which specific models are applications. The existence of 'numerous economic models' does not imply methodological fragmentation. But it does facilitate, though it does not require, specialization.

Beyond the scope of this essay is a discussion of the abuse of mathematics as a tool for deriving economic theorems. However, I do not wish to deny that abuses exist. Clearly some works in 'mathematical economics' are sterile of economic content. They are fashioned by assumptions made to accommodate mathematical convenience not economic reality. At worst, mathematical symbols are manipulated, given economic names, and the results then called economics. Nor is there a wish to minimize the intellectual investment necessary to learn the language and techniques of mathematics or to fail to recognize that this intellectual effort can be invested profitably elsewhere by the economist.

However, the purpose of this essay is not to discuss the strengths and limitations of mathematical economics. Its goal is to present a balanced, if critical, review of the Misesian case against mathematical economics. It is an essay in search of methodological congruence and, therefore, tolerance. Praxeology and neo-classical mathematical economics share a common philosophic foundation and differ primarily in their respective styles of theorizing. The profound questions raised by praxeologists have been and will continue to be addressed by those theorists who make use of mathematics. The conceptional predisposition and narrow confines of the constrained optimization approach to theorizing can be overcome. The praxeologist and neo-classical mathematical economist are not methodological foes. The real philosophic gulf is with the Marxists and Neo-Ricardians who systematically reject methodological individualism and subjectivism.

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## Notes

- 1 Ludwig von Mises, *Human Action: A Treatise on Economics*, 3rd revised edition, (Chicago: Henry Regnery, 1966), 57.
- 2 Alpha C. Chiang, *Fundamental Methods of Mathematical Economics*, 3rd edition, (New York: McGraw-Hill, 1984), 3. Italics in the original.
- 3 Ludwig von Mises, *Human Action; The Ultimate Foundations of Economic Science: An Essay on Method* (Kansas City, MO: Sheed, Andrews, and McMeel, 1978), and *Epistemological Problems of Economics*, trans. George Reisman, (New York: New York University Press, 1981).
- 4 Mises, *Human Action*, 64.

- 5 Murray N. Rothbard, "Praxeology: The Methodology of Austrian Economics", in Edwin G. Dolan, ed., *The Foundations of Modern Austrian Economics* (Kansas City, MO: Sheed and Ward, 1976), 20.
- 6 Mises, *Human Action*, 39.
- 7 *Ibid.*, 34.
- 8 Rothbard, "Praxeology ...", 24.
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