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The Visible Hand

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Tribute to Martin Shubik

1. "Accounting and its Relationship to General Equilibrium Theory" by Martin Shubik, https://doi.org/10.1515/ael-2018-0054
2. "Martin Shubik's Curriculum Vitae" by Shyam Sunder, https://doi.org/10.1515/ael-2019-2047
3. "The Visible Hand" by Andrew W. Lo, https://doi.org/10.1515/ael-2018-0012
4. "What Makes Money Work? Comments on "The Guidance of an Enterprise Economy"" by Joel Sobel, https://doi.org/10.1515/ael-2018-0012
5. "Institutions, Games and Economic Theory: Comments on the Guidance of an Enterprise Economy by Martin Shubik and Eric Smith, MIT Press 2016" by Douglas W. Diamond, https://doi.org/10.1515/ael-2019-0047
6. "Equilibrium and System Analysis in Economic Dynamics. A Comment on the "Guidance of an Enterprise economy" by Martin Shubik and Eric Smith" by Yuri Biondi, https://doi.org/10.1515/ael-2018-0027

It is a rare pleasure and honor for a former undergraduate student in Martin Shubik's popular game theory classes at Yale University to be asked to write a review of his professor's latest book, *The Guidance of an Enterprise Economy*, published by MIT Press in 2016. In contrast to the old saw in which "the student is now the master," this volume confirms that the student is still the student and the master is—and always will be—the master.

Shubik, the world-renowned game theorist, and his co-author, Eric Smith, an impressive physicist cum biologist cum economist at the Santa Fe Institute, have undertaken an ambitious agenda to formulate a grand synthesis of the different levels of economic theory—financial, microeconomic, organizational, and macroeconomic—and reintroduce dynamics within the framework of general equilibrium (GE). They have written a fascinating, provocative, and occasionally frustrating volume that moves a much-neglected topic forward.

Students of economics will recall that the concept of GE is a set of prices and quantities for all goods and services in an economy that simultaneously causes producers to produce exactly what and how much consumers want to consume, and consumers to consume exactly what and how much producers want to produce. In other words, this very special set of prices and quantities equalizes supply and demand in every market, for every producer and consumer, all at the same time. For a complex economy like ours, the thought that we might all be simultaneously satisfied with exactly what we're producing or consuming might seem so far-fetched as to be irrelevant. Therefore, it was a major achievement of modern economics when McKenzie (1954) and Arrow and Debreu (1954) independently proved in a formal mathematical framework that under certain conditions, such general equilibria exist and are unique. GE is a powerful idea, the keystone at the heart of virtually all of modern economics, including models used for policy decisions ranging from taxes to Fed interest-rate changes to international trade.

The intellectual origins of GE go back to the 1870s and the work of French economist Leon Walras, who proposed a mechanism of "tatonnement," or trial-and-error, through which a hypothetical intermediary would facilitate the discovery of a GE by calling out prices and adjusting them up incrementally in the face of excess demand and down in the face of excess supply until supply and demand are equalized across all markets. Despite the importance of this "Walrasian auctioneer" in achieving GE, most economists regarded the concept as little more than a pedagogical device, intended to illustrate the practicality of a purely theoretical notion, although Walras's treatment of tatonnement was considerably more sophisticated.[1] Although a few formal models of "disequilibrium dynamics" have been proffered (more on this later), most students of GE, and most economists today, prefer to focus instead on the properties of equilibria rather than try to come up with explanations of how we got there.

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Ironically, although policy applications are almost always dynamic—meaning that they involve time-varying behaviors and circumstances—the theory of general equilibrium is essentially static. In fact, to many purists, this is a feature, not a bug. For example, in extending the theory of GE to the case of uncertainty, Arrow (1964) introduces the notion of "state-contingent claims," essentially converting a dynamic problem of how the unknown future resolves over time into a static problem of choosing among a much larger set of securities, each with a payoff contingent on a specific future state of the world. It wasn't until Robert Merton's (1973) derivation of the Black-Scholes/Merton option-pricing formula that the deep connection was made between static state-contingent claims and dynamic "delta-hedging" trading strategies capable of replicating the payoffs of Arrow-Debreu securities.

Shubik and Smith (S&S) take a different tack in *The Guidance of an Enterprise Economy*. Rather than employing Merton's continuous-time framework and Ito stochastic differential equations, they introduce dynamics to the static, "timeless" viewpoint of GE through the addition of money and the periodization of time into strategic market games, beginning with the one-shot case, then extending it into the multi-period case through the introduction of process, one-way steps modeling production, consumption, and innovation. S&S appeal to the concept of the "minimal institution," the formal model with the least complexity of an institution to specify its necessary functional requirements. While complexity is difficult to measure, they present this as broadly analogous to such concepts as the minimum description length in information theory, or the lowest-order algebraic representation of an effective field theory in physics.[2]

One can think of the minimal institution as the simplest mathematical description of the desired economic phenomenon. They believe that these minimal institutions will be few in number and that this will make the "hyperastronomical" combinatorial explosion of possible models much more tractable to analysis.

The models in the first half of the book follow a succession of quasi-historical approximations of economic complexity, from a world before economic institutions that uses only barter, to the monetary decision of choosing between a metallic or fiat currency, to the growth of liquidity and financial bubbles. This arrangement perhaps owes something to Smith's studies on the origin of life, although the models themselves are strongly influenced by physics, for example, thermodynamics.[3] The second half of the book, however, becomes more hypothetical, loosening its metaphorical collar to explore the effects of mechanism and flow within the authors' framework, with the final chapter presenting a sketch of the use of dynamic "ad hoc" models as guidance (as the title indicates) of an economy, which the authors candidly admit may be more difficult than weather control.[4]

This candor also expresses itself when S&S consider the difficult challenge of developing the necessary instruments to analyze and implement these potential solutions. Instead of a grand unified theory of economics, they engage in theoretical creative destruction[5] and propose smaller domains of interest, stitched together under the big tent of GE and the constraints of the material world. Instead of divisions into microeconomics and macroeconomics, they suggest a split of economics into one like the split between physics and engineering. As in physics, they use symmetries to add simplifying structure to solutions and dimensional analysis to estimate forms and values. For instance, S&S demonstrate rather elegantly how an all-for-all barter market loses its formal symmetry with the introduction of cash and credit, and then is able to gain a new symmetry with the addition of bankruptcy and monetized personal credit.[6] More speculatively, S&S make the occasional analogy to ecology and the biological sciences, for instance, comparing the number of levels of regulatory or financial derivative complexity to the trophic levels in an ecosystem.[7] However, they believe this area is too much "in a state of flux" to be more than a set of compelling "analogies and metaphors."[8] In this one respect, I must beg to differ with the master, given my own perspective on adaptive markets and the very direct and quantifiable role that evolution plays in market dynamics and economic growth and decline.[9]

It's hard not to be sympathetic to S&S's goal of restoring dynamics to the unreasonably static framework of GE. We economists are so enamored by the mathematical elegance of Arrow and Debreu's formulation of GE that it's easy to forget about the practical elements of the price discovery process. A stint on the floor (or a glimpse at the screens) of any modern stock or futures exchange should convince even the most fervent GE disciple that the Invisible Hand occasionally experiences carpal tunnel syndrome.

In much the same way, the dynamics of price formation have been neglected. In fact, it was considered a great victory for the rational expectations revolution to replace the apparent periodicity of commodity cycles and Kaldor's cobweb model with Muth's belief that "dynamic economic models do not assume enough rationality."[10] That revolution overthrew the old order, but along the way, it also foreswore its dynamic origins. Now we have an infinity of equilibrium prices, without any thought as to how to get from one equilibrium to another.

S&S's use of game theory is also important. Clearly, one central aspect of human behavior is the strategic, the layer upon layer of motivation, action and reaction in the hall of mirrors of the human theory of mind. Thus, S&S distinguish between eight basic types of behavior, ranging from the naive player who is unaware even of the rules of the game, to that old standby, *Homo economicus*, the perfect optimizer, whom they call the "von Neumann player."[11] Instead of limiting an agent's ability in the manner of Herbert Simon's satisficing, to use a familiar example, they define the abilities of an agent by the different domains of knowledge available to that agent, comparing the retired surgeon with $10 million to invest to the professional financier with the same amount.[12]

The authors admit there are outstanding issues within this framework, for example, the related problems of aggregation and the continuum. Economic processes operate at timescales from microseconds to decades, and the range of economic actors can vary from a penniless refugee to a trillion-dollar sovereign wealth fund. However, S&S's method of aggregation is ad hoc, even for a framework that celebrates the ad hoc, although this is not an insurmountable objection (perhaps by using classification algorithms from the recently developed arsenal of machine-learning tools?). More concerning is their hope that dynamically simple models will capture aggregate economic behavior more effectively than they do individual behavior, which is far from proven.[13]

S&S diagnose the problem clearly enough. "Unfortunately ... unlike the use of mathematics in much of physics, in economics the mathematics almost took on a life of its own, and the gap between elegant mathematical models and the ongoing reality of the phenomena has widened."[14] Yet their solution is mathematics that looks a lot like physics. Above the level of strategic market games, GE becomes the framework under which markets clear and equations balance, and the search for a useful invariant quantity is a recurring theme of the book, although S&S reluctantly conclude that any invariants are "at a level far from immediate application."[15]

Physicists themselves have long since recognized equilibrium is not a strong starting point to understand dynamics; it's hard to reconstruct the fall of a broken teacup from the shards and puddles on the floor. S&S are still a bit too attached to the decades-old tendency to "mathematize" economics. Mathematics plays a useful role on the economic stage, but it need not always be the leading one. All too often, the introduction of mathematics serves to obfuscate rather than to clarify the underlying phenomenon. As Paul Samuelson wrote presciently in his 1947 Ph.D. thesis, as if to warn those attempting to follow in his formidable mathematical footsteps[16]:

> ... [O]nly the smallest fraction of economic writings, theoretical and applied, has been concerned with the derivation of operationally meaningful theorems. In part at least this has been the result of the bad methodological preconceptions that economic laws deduced from a priori assumptions possessed rigor and validity independently of any empirical human behavior ... We do not have to dig deep to find examples. Literally hundreds of learned papers have been written on the subject of utility. Take a little bad psychology, add a dash of bad philosophy and ethics, and liberal quantities of bad logic, and any economist can prove that the demand curve for a commodity is negatively inclined."

However, there are a number of possible extensions to their framework that might preserve and sharpen S&S's insights. One possibility is through greater use of simulation. For example, the agent-based modeling of Smith's former Santa Fe Institute colleague Doyne Farmer and others seems a natural fit for their strategic market games.[17] While this may involve a greater complexity of agents, it would also increase behavioral richness. In a somewhat different direction, there is the systems dynamics literature, pioneered by Jay Forrester, involving stocks and flows in a manner that could be adapted to S&S's conceptual framework, but also using feedback loops and time lags to produce a variety of complex behaviors from simple components.[18]

There is also a much older "road not taken," away from the austere, fixed-point GE of Arrow and Debreu, that leads to convincing dynamics. This is exemplified by the disequilibrium economics of Franklin Fisher[19] and the much older work of Takashi Negishi.[20] It may seem like ancient history today, but instead of using the global condition of Walras's Law, i. e., that the total excess demand of a system must equal zero, Negishi used the local behavior of the excess demand function to demonstrate the dynamic stability of general equilibrium. As a result, Negishi's method is much more amenable for use in a dynamic theory. (In an interesting historical note, papers using the global condition were submitted almost simultaneously by Hahn and by Arrow and Hurwicz, only weeks before Negishi's paper reached *Econometrica*, thus giving them precedence.) Negishi's use of the excess demand function seems very similar to S&S's call for a model with "shadow prices measuring the pressures calling for the change in constraints, or perhaps signaling slack conditions of oversupply."[21]

Finally, there is a radical solution to S&S's dilemma. If GE is only present to preserve a handful of identities, why not throw out GE entirely? Instead, strategic interactions throughout the entire economy would generate dynamics, much as they do in the real world. Without GE, of course, a different constraint on agent behavior will be needed. S&S make the observation that physical law is a necessary constraint on economic behavior, but we as a species are very far from pressing the boundaries of the laws of physics and current limitations on natural resources are primarily technological, not absolute, and thus subject to change.

I suspect that S&S would agree that economics is only a special case of biology. My suggestion, then, is to use biological and ecological principles as their constraints, and investigate the resulting interactions of economic interest. As the evolutionary biologist Theodosius Dobzhansky said, "nothing in biology makes sense except in the light of evolution." For example, if an S&S economy consists of strategic interactions between a number of small agents and one large atomic agent representing the government, one might model the government as responding to its environment (the behavior of small agents), creating variations in its policies across many degrees of freedom—including taxation, subsidies, interest rates, money supply, reserve ratios, national debt limits, and securities issuance, to borrow S&S's list[22] —and inheriting the most successful ones over time. Its policies would be subject to natural selection based on the economic environment. This perspective would allow us to reintroduce the concept of the minimal institution as a deliberate environmental constraint, including the government behaving as a regulatory agency. Thus, instead of political pundits telling us that "it's the economy, stupid!", biologists should be reminding us economists "it's the environments, stupid!"

In the end, where does this leave us? S&S have done the profession a great service in bringing us away from static GE and reintroducing time and change into the literature. I hope we can go even farther than that and move away from the false precision of mathematical physics applied to economics, using more realistic agents and constraints, even at the expense of elegant but often irrelevant models and closed-form solutions. After all, shouldn't we strive to be approximately right rather than precisely wrong?

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We mourn the loss of Martin Shubik (1926 – 2018), a gifted scholar and a dear friend. Through his remarkable ideas and insights, Shubik helped founding and shaping the CONVIVIUM with his guidance, advice, and inaugural contribution "Accounting and Economic Theory: Past, Present, and Future" (DOI: https://doi.org/10.2202/2152-2820.1012). At the time of his passing on August 22, 2018, editorial work on this symposium on his last book with Eric Smith, *The Guidance of an Enterprise Economy*, has been underway. It is now published to honour him and his outstanding contributions to economics, management science, game theory, and accounting scholarship.

Notes

1 See, for instance, Walker (1987).
2 Shubik and Smith (2016), p. 9.
3 *Ibid*., pp. 68–69.
4 *Ibid*., p. 509.
5 My thanks to Biondi (2018) for this splendid turn of phrase.
6 *Ibid*., pp. 86–98.
7 *Ibid*., pp. 429–430.
8 *Ibid*. p. 437.
9 Lo (2017) and Lo and Zhang (2018).
10 Muth (1961).
11 Shubik and Smith (2016), p. 10.
12 *Ibid*., pp. 422–423.
13 *Ibid*., pp. 44–45.
14 *Ibid*., p. 6.
15 *Ibid*., p. 512. S&S speculate that the Pareto distribution of income is an example of one such invariant (pp. 290–291).
16 Samuelson (1947, p. 3).
17 See Geanakoplos et al. (2012) and Bookstaber, Paddrik, and Tivnan (2014).
18 See, for example, Sterman (2000).
19 Fisher (1983).
20 Negishi (1958).
21 Shubik and Smith (2016), p. 7.
22 *Ibid*., p. 388.

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