Beyond DSGE Models: Towards an Empirically-Based Macroeconomics

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Abstract

This paper argues that macro models should be as simple as possible, but not more so. Existing models are "more so" by far. It is time to step beyond representative agent, DSGE models and focus more on alternative heterogeneous agent macro models that take agent interaction, complexity, coordination problems and endogenous learning seriously. It further argues that as analytic work on these models continues, policy-relevant models should be more empirically based; policy researchers should not approach the data with theoretical blinders on; instead, they should follow an engineering approach and let the data guide their theory choice.

Beyond DSGE Models: Towards an Empirically-Based Macroeconomics

Maybe there is in human nature a deep-seated perverse pleasure in adopting and defending a wholly counterintuitive doctrine that leaves the uninitiated peasant wondering what planet he or she is on.—Robert Solow[1]

There has, for some time, been a strong undercurrent of opposition to modern macroeconomic models which, in their latest incarnation, have coalesced around dynamic stochastic general equilibrium models. Critics ask: How can a model that assumes away any agent coordination problems shed much light on macro phenomena that are intrinsically involved with such problems? They argue that what makes macroeconomics a separate field of study is the complex properties of aggregate behavior that emerge from the interaction among agents. Since in a complex system aggregate behavior cannot be deduced from an analysis of individuals alone, representative agent models fail to address the most basic questions of macroeconomics.

To many young economists who are unfamiliar with the history of macro, the thought of doing macro without representative agent micro foundations is almost heretical. How can one hope to say anything formally about the macro economy without "sound microfoundations"? To do so, they have been taught, would be ad hoc. In truth, however, nothing could be more ad hoc than the standard microfoundations; as economists such as Pareto, Hicks, and Koopmans have made clear, the assumptions we make about individuals in microeconomics are based on introspection, not on any mass of coherent empirical evidence or even on any intuitive plausibility criteria. The only

[1] Robert Solow (2006) made this statement when he was reflecting on how the macro model had gone so far astray. He further states that "(flaws in the previous model) would not explain why the macro community bought so incontinently into an alternative model that seems to lack all credibility."

justification of the hyper-rational, self-interested agent typically used in standard macro models was that it was consistent with the characterization used in micro theorizing. And even that justification is now disappearing with the rise of behavioral economics.

To make the needed break from the past, macroeconomists must acknowledge that micro foundations are a choice variable of theorists. The appropriate choice cannot be determined a priori; it needs to be made in reference to empirical data and educated common sense in a way that will lead to useful macro models. The current standard approach in macro does not do that; instead it clings to the rational, self-interested agent microfoundations. Then, as discussed in Kirman (1992) to avoid the Sonnenschein-Mantel-Debreu aggregation problem—namely the problem that the aggregation of individual behaviors does not generally inherit the nice properties of those agent behaviors--it makes the additional ad hoc representative individual assumption.

A more reasonable approach to macro theory would recognize that the behavior of the aggregate need not correspond to the behavior of the components, nor can it generally be derived from a consideration of the latter alone. *Any meaningful model of the macro economy must analyze not only the characteristics of the individuals but also the structure of their interactions.* Such a view is commonplace in other disciplines from biology to physics and sociology. They recognize that the aggregate behavior of systems of particles, molecules, neurons, and social insects cannot be deduced from the characteristics of a "representative" of the population. The same is true for economic systems; the fallacy of composition exists, and must be dealt with. (Howitt, 2006)

The above arguments have been stated many times before. Why then are we hopeful that restating them again is worthwhile? The reason for our optimism is that the tools and technology necessary to build complex models are being assembled and increasingly applied by the economics profession. These new tools, which are being adapted from disciplines as varied as physics, biology,

computer science and psychology, allow the profession to move beyond DSGE models to more comprehensive, and potentially more meaningful, models. The other papers in this session provide an introduction to some of these approaches, tools, and models. In this paper we simply try to put them into perspective, and to encourage young economists to pursue this sort of approach.[2]

To understand why we are convinced that this is the right way to move forward in macro, it is helpful to briefly review the history of the field. Up until the 1940s or 1950s, macroeconomics proceeded without a formal theory. Macroeconomic policy was based on a loose and largely empirical understanding of the macro economy. The field advanced through trial and error, as economists learned from the experience of the past, in the same way that stonemasons learned from the past as they developed methods to build cathedrals long before they understood the formal scientific principles that determine whether or not their constructions would fall down. Similarly, economists used simple, informal macro models, such as the quantity theory and the Keynesian Cross, that captured elements of the macro economy and provided guidance for policy, all in advance of the necessary formal scientific principles. Economic theory had not moved into its axiomatic and mathematical phase at that time, so the idea of a macroeconomic model based on axioms concerning individual behavior was not even envisaged.

While we are sympathetic with this engineering approach for policy purposes, and will argue that there is a modern day equivalent to this earlier approach that economists can benefit from using today, the approach is justifiable only if its limitations are kept in mind. As an engineering model, it is about solving immediate problems and it does not provide a scientific understanding of the way in which the macro economy functions, nor is it intended to do so. This has not always been recognized.

[2] The papers in this session expand upon the criticisms and developments presented in Colander, ed. (2006).

With the development of macro econometric models in the 1950s, many of the Keynesian models were presented as having formal underpinnings of microeconomic theory and thus as providing a formal model of the macro economy. Specifically, IS/LM type models were too often presented as being "scientific" in this sense, rather than as the ad hoc engineering models that they were. Selective micro foundations were integrated into sectors of the models which give them the illusory appearance of being based on the axiomatic approach of General Equilibrium theory. This led to the economics of Keynes becoming separated from Keynesian economics

The exaggerated claims for the macro models of the 1960s led to a justifiable reaction by macroeconomists wanting to "do the science of macro right", which meant bringing it up to the standards of rigor imposed by the General Equilibrium tradition. Thus, in the 1970s the formal modeling of macro in this spirit began, including work on the micro foundations of macroeconomics, construction of an explicit New Classical macroeconomic model, and the rational expectations approach. All of this work rightfully challenged the rigor of the previous work. The aim was to build a general equilibrium model of the macro economy based on explicit and fully formulated micro foundations.

Given the difficulties inherent in such an approach, researchers started with a simple analytically tractable macro model which they hoped would be a stepping stone toward a more sensible macro model grounded in microfoundations. The problem is that the simple model was not susceptible to generalization, so the profession languished on the first step; and rational expectations representative agent models mysteriously became the only allowable modeling method. Moreover, such models were directly applied to policy even though they had little or no relevance. The result was the situation that the Solow quote refers to in the beginning of this paper.

The reason researchers clung to the rational expectations representative agent models for so long is not that they did not recognize their problems, but because of the analytical difficulties involved in moving beyond these models. Dropping the standard assumptions about agent rationality would complicate the already complicated models and abandoning the ad hoc representative agent assumption would leave them face to face with the difficulties raised by Sonnenschein, Mantel and Debreu. While the standard DSGE representative models may look daunting, it is the mathematical sophistication of the analysis and not the models themselves which are difficult. Conceptually, their technical difficulty pales in comparison to models with more realistic specifications: heterogeneous agents, statistical dynamics, multiple equilibria (or no equilibria), and endogenous learning. Yet, it is precisely such models that are needed if we are to start to capture the relevant intricacies of the macro economy.

Building more realistic models along these lines involves enormous work with little immediate payoff; one must either move beyond the extremely restrictive class of economic models to far more complicated analytic macro models, or one must replace the analytic modeling approach with virtual modeling. Happily, both changes are occurring; researchers are beginning to move on to models that attempt to deal with heterogeneous interacting agents, potential emergent macro properties, and behaviorally more varied and more realistic opportunistic agents. The papers in this session describe some of these new approaches

One important characteristic of this new work is that it is uninterested in full agent model equilibria. As biologist Stuart Kaufman has remarked, “An organism in equilibrium is dead.” Instead, it looks for *system equilibria,* in which agent disequilibria offset each other so that the aggregate system is unchanging, even though none of the components of the individual agents in the model are in equilibrium. Aggregate systems in equilibrium have lots going on inside them, and the goal of this

work is to relate the micro dynamics with the macro equilibrium. This places the models in the realm of statistical mechanics, and opens up a new range of tools, such as cluster analysis and ultrametrics, which can be used to explore them. (Aoki and Yoshikawa, 2006) It even offers the possibility of jettisoning all micro foundations, and, using dimensional analysis, analyzing the aggregate economy with zero-rationality agents, as the econophysics literature is doing. (Doyne Farmer, et al, 2006)

All this work is both statistically and mathematically technical. The simple truth is that formal macro theorizing that extends beyond where we currently are can no longer be done by the general macro economic theorist without specialized knowledge of various branches of mathematics and statistics, in the same way that theoretical physics cannot be done by engineers or applied physicists alone. With the increase in technical sophistication of the tools now available, scientific economics is at the stage where it must give up the notion that a generalist macroeconomic scientist can do it all, policy, theory, and empirical work.

The way that macroeconomic theorists have kept ahead of the game till now has been to concentrate on a very specific part of mathematics applicable to the set of restricted models that they use. That approach does not work. If we are to develop newer, more encompassing macroeconomic theories modern macroeconomists must see themselves as a collection of specialists in various techniques and approaches working together to solve a very complicated problem.

ACE Modeling

Because the analytic macro models discussed above are so technically difficult, it is not clear which, if any, will provide a meaningful advance. However, because of the increase in computing power over the past decade, there is another approach that cuts the Gordian analytic knot and uses agent based computational economic (ACE) models to analyze the macro economy. In ACE models

researchers create virtual worlds that can be used as test beds to study macroeconomic phenomena. The ACE modeling method is described in the LeBaron/Tesfatsion paper.

The advantage of the ACE approach for macroeconomics in particular is that it removes the tractability limitations that so limit analytic macroeconomics. ACE modeling allows researchers to choose a form of microeconomics appropriate for the issues at hand, including breadth of agent types, number of agents of each type, and nested hierarchical arrangements of agents. It also allows researchers to consider the interactions among agents simultaneously with agent decisions, and to study the dynamic macro interplay among agents. Researchers can relatively easily develop ACE models with large numbers of heterogeneous agents, and no equilibrium conditions have to be imposed. Multiple equilibria can be considered, since equilibrium is a potential outcome rather than an imposed requirement. Stability and robustness analysis can be done simultaneously with analysis of solutions.

The Engineering Approach: Taking the Models to Policy

We are a long way from analytic and ACE models being intuitively satisfying. For example, in a truly satisfying ACE model, the agents will have access to ACE modeling results, making the modeling process itself endogenous to the model. That was the problem that John Muth attempted to sidestep with his assumption of rational expectations. But process endogeneity cannot be sidestepped; endogenous process systems continually unfold in ways that likely can never be fully understood from a vantage point within the system. Because of the inherent complexity of the problem, even the new advanced analytic and ACE macro models described above should be seen as stepping stones on the path to a deeper model of macro sometime in the future. However, they are still far too simple to bring directly to policy; they are, at best, suggestive. Thus, researchers must be careful about drawing

anything other than suggestive inferences about macro policy from the models. Ad hoc models, as all scientific macro models are at this point, provide ad hoc policy advice; they can do no better.

If all scientific macro models are still ad hoc, how should one undertake macro policy today? Our answer is that policy economists need to go back to the engineering approach that economists used up until the 1940s and 50s. That engineering approach does not search for scientific understanding; it searches for models that shed light on the problems at hand. Because of the statistical and computational advances that have been made in the past half century, the modern macro engineering approach will not be limited to the heuristic and ad hoc econometric models that they used, but instead can use sophisticated statistical models to complement our understanding. It is time to return to an engineering approach to macro policy that has long existed in econometrics, and accept that one can and should search for relationships among macroeconomic variables without worrying about the behavioral foundations of those relations.

The use of vector auto-regression models which posit linear relations among various macro time series is one way to do this. These models do away with the restrictive assumptions of causal models such as DSGE, and thus are a good starting point for a modern engineering macro model. Such an approach is now widely used to make forecasts and to guide macro policy. Today, in particular, for short-term forecasts and analysis, researchers are more and more turning away from formal theoretical models of any type and are using VAR models.

That approach makes practical sense, but as all researchers know, statistical models alone do not provide answers; one's theory influences one's interpretation of the statistical models. The question is: How do we integrate the statistical results with our theories? One approach being suggested is to use DSGE models as Bayesian priors for the analysis. (Del Negro and Schorfheider, 2004) We find that approach unsatisfying. We believe that the Brock/Durlauf/Rondina paper offers a

more reasonable approach that assumes the "true" macro model is unknown, and entertains multiple candidate theories.

The Hoover/Johansen/Juselius paper offers an alternative attractive approach that switches the role of theory and statistical analysis. Instead of letting theory guide data, they let the data guide both policy and theory choice. The central tools in this approach are cointegrated vector auto regressive statistical models, and general to specific statistical modeling. These tools allow the researcher to take an archeological approach to the data—relying on the statistical tools to guide the policy maker in finding the stable statistical relations among variables in the past.

This modern engineering approach requires continuous interaction between the researcher and the data. Cointegration does not lead to clear-cut answers, and to make decisions about the grey areas, the researcher must have a good sense of the strengths and weaknesses of the various theories. Results will vary according to the decisions he or she makes, and thus the results are researcher specific. To make reasonable decisions, the researcher cannot hold just one theory. Doing so will all too often simply lead the researcher to confirm whatever theory he holds (See Johansen, 2006). In short, the modern macro engineering researcher cannot be a technician who applies technical tools to data, but rather must be a craftsman who integrates the best computer aided statistical analysis possible with the best general theoretical and institutional knowledge, allowing him or her to interpret the data.

Conclusion

Einstein once said that models should be as simple as possible but not more so. If the macro economy is a complex system, which we think it is, existing macro models are "more so" by far. They need to be treated as such. We need to acknowledge that our current representative agent DSGE models are as ad hoc as earlier macro models. There is no exclusive right to describe a model as "rigorous". This does not mean that work in analytical macro theory should come to a halt. But it

should move on to models that take agent interaction seriously, with the hope that maybe, sometime in the future, they might shed some direct light on macro policy, rather than just provide suggestive inferences. In the meantime, the best approach to macro policy is to come back to earth and to adopt an engineering approach in which macro econometricians see themselves as builders not architects.

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