Computational Macroeconomics for the Open Economy

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Preface

This study comes from the conviction that policy makers need quantitative, not simply qualitative, answers to pressing policy questions. Policy makers have to make decisions in the real world, and it is often useful, if not imperative, to augment qualitative advice with specific numerical ranges for operational targets in the short and medium run. For example, while it is useful for economic advisors to inform policy makers about the need for a competitive real exchange rate, or a sustainable trade deficit, it would be even more useful for the advice to include some benchmark numerical values of the competitive real exchange rate, or the sustainable trade balance (given the magnitudes of the key characteristics of the economy and external conditions)

Quantitative answers have often come from ad hoc back-of-envelope calculations, or cursory eyeballing of charts and graphs, based on incomplete partial equilibrium models with simple backward-looking expectations. Today quantitative policy-useful recommendations can come from a rigorous analysis of well-specified, internally coherent macroeconomic models, calibrated to capture key characteristics of particular real world situations. Good economic policy evaluation today is thus about providing quantitative, not simply qualitative, answers to pressing questions.

The way toward more effective quantitative policy analysis is through the use of computational stochastic nonlinear dynamic general equilibrium models. This study shows how such models may be made accessible and operational for confronting policy issues in highly open economies.

Wider use of computational experiments or simulation-based policy evaluation, based on stochastic nonlinear dynamic general equilibrium models, is now possible due to recent advances in computational methods, as well as faster, less costly, and more widely available

computers. Newer algorithms permit the analysis of models which are not only *sufficiently complex* so that interesting questions may be explored, but also *tractable enough* so that one may be able to assess the sensitivity of results to particular assumptions and initial conditions.

Furthermore, it is no longer necessary to think linearly. For many years it was necessary to linearize the nonlinear first-order conditions of such models around a long-run steady state in order to make these models operational for estimation, computer simulation, and subsequent policy evaluation. Physicist Richard Feynman, for example, asks the question, why are linear systems so important? There is only one answer, and that answer, he states, is simply that we can solve them (see Feynman, Leighton and Sands 1963).

While such linearization makes estimation and simulation relatively fast, it frequently throws out the baby with the bath water, since many of the interesting questions in macroeconomic adjustment—such as asymmetric response of asset prices to shocks, or the effects of risk on economic welfare—necessitate explicit nonlinear approaches. For example, why do currencies crash spectacularly fast but recover much more slowly? Such phenomena do not take place in linear symmetric environments.

More to the point, many of the changes in external or internal environments facing decision makers in small highly open economies hardly represent small or local departures or movements around a steady state. Similarly the movements of key financial variables, such as asset-market returns, have hardly been linear and symmetric. As Franses and van Dijk (2000, p. 5) point out, such returns display erratic behavior, in the sense that "large outlying observations occur with rather high-frequency, large negative returns occur more often than large positive ones, these large returns tend to occur in clusters, and periods of high volatility are often preceded by large negative returns."

Miranda and Fackler (2002, p. xv) point out that economists have "not embraced numerical methods as eagerly as other scientists" perhaps "out of a belief that numerical solutions are less elegant or less general than closed-form solutions." However, the development of parameterized expectations, collocation methods, neural network approximation, and genetic algorithms, as well as other methods, have opened the way to use relatively complex nonlinear models for policy analysis and evaluation. As Kenneth Judd reminds us in his book, *Numerical Methods in Economics*, models, to give meaningful insight to policy makers, must be simple, but the models should not, and need

not be, too simple. This study shows how state-of-the-art tools may be used to apply sufficiently complex models in computational experiments to give meaningful insights, under realistic assumptions about the underlying economic environments.

This book is, in part, a stand-alone research treatise and a stand-alone graduate textbook. It is like a research treatise in the sense that it contributes to current research knowledge in the area, but in a more extensive format than would be common in an academic journal article. It is like a graduate textbook, in the sense that it aims to help students and researchers get up to speed on computational methods and to apply these techniques to interesting questions. Finally, it is a policy-oriented book, intended to help researchers at central banks build their own models for ongoing analysis and evaluation.

Of course, all models are limited. As Martin Feldstein observes, in his tribute to Otmar Issing (when he departed as a member of the Board of the European Central Bank), our computational models are "only useful as heuristic devices to help clear our thinking" rather than for specifying real time policies, and that we are "particularly poor at open economy issues" (Feldstein 2006). We hope that this book contributes to clear thinking about open economy issues, as well as the design of better policies even in real time.

While remaining a stand-alone book, this study may also be seen as a distillation of several ideas coming from *Numerical Methods in Economics* and *Foundations of International Macroeconomics*. Both of these books are widely used sources for learning the literature in computational methods and open economy macroeconomics respectively.

We stress at the outset that this book is concerned with monetary and fiscal policy, for a prototype small open economy. We do not try to capture the environment of any economy in particular, through methods for "matching moments" of simulated and actual data, or with Bayesian estimation. Rather, we intend to show the important trade-offs in the conduct of policy under familiar and realistic scenarios taking place in small open economies throughout the world.

The organization of the material in the book is influenced by our experience with graduate students and with policy researchers. As professors, both of us recognize that students and researchers face significant learning setup costs (including psychological adjustment costs!) when they contemplate the implementation of computational algorithms. Common reactions among many of our current and former students and colleagues include feelings that they are delving into a

"black box," that they have to learn the "art and science" of program-ming cumbersome code, that they have to wait long hours or even days for computer programs to "converge," and finally, that they have to live with the lingering uncertainty about the "accuracy" and "uniqueness" of the numerical results, as well as their policy relevance, once they have taken the time and trouble to do the computational work. Small wonder, then, that many prefer to work with simplified, linear, analytically tractable models, even if the assumptions are at times highly artificial and abstract.

We wish to show that the "black box" is not as dark as many think when viewed through the lens of a "random search" solution algo-rithm, that popular algorithmic methods can be understood rather quickly and are well worth the investment in time and energy, that "convergence waiting time" is often not that much longer than the "programming cost" of setting up linear models with equally cumber-some log-linear algebraic approximation, that "accuracy checks" for models are easily implemented, and that these models yield important new insights into dynamic macroeconomics for open economies.