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# Solving Dsge Models With Perturbation Methods And A Change

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## JAIR RIVAS

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### Handbook of Computational Economics

Newnes

In an environment where economic structures break, variances change, distributions shift, conventional policies weaken and past events tend to reoccur, economic agents have to form expectations over different regimes. This makes the regime-switching dynamic stochastic general equilibrium (RS-DSGE) model the natural framework for analyzing the dynamics of macroeconomic variables. We present efficient solution methods for solving this class of models, allowing for the transition probabilities to be endogenous and for agents to react to anticipated events. The solution algorithms derived use a perturbation strategy which, unlike what has been proposed in the literature, does not rely on the partitioning of the switching parameters. These algorithms are all implemented in RISE, a flexible object-oriented toolbox that can easily integrate alternative solution methods. We show that our algorithms replicate various examples found in the literature. Among those is a switching RBC model for which we present a third-order perturbation solution.

*Handbook of Macroeconomics*

Cambridge University Press

This paper reviews Bayesian methods that have been developed in recent

years to estimate and evaluate dynamic stochastic general equilibrium (DSGE) models. We consider the estimation of linearized DSGE models, the evaluation of models based on Bayesian model checking, posterior odds comparisons, and comparisons to vector autoregressions, as well as the nonlinear estimation based on a second-order accurate model solution. These methods are applied to data generated from correctly specified and misspecified linearized DSGE models, and a DSGE model that was solved with a second-order perturbation method.

*The Oxford Handbook of Bayesian Econometrics* International Monetary Fund

This paper compares different solution methods for computing the equilibrium of dynamic stochastic general equilibrium (DSGE) models with recursive preferences such as those in Epstein and Zin (1989 and 1991). Models with these preferences have recently become popular, but we know little about the best ways to implement them numerically. To fill this gap, we solve the stochastic neoclassical growth model with recursive preferences using four different approaches: second- and third-order perturbation, Chebyshev polynomials, and value function iteration. We document the performance of the methods in terms of computing time, implementation complexity, and accuracy. Our main finding is that a third-order perturbation is competitive in terms of accuracy with Chebyshev polynomials and value function iteration,

while being an order of magnitude faster to run. Therefore, we conclude that perturbation methods are an attractive approach for computing this class of problems.

*Heterogeneous Agent Modeling* Emerald Group Publishing

*Solving DSGE Models - When Local Approximations Fail*

*Solving DSGE Models - When Local Approximations Fail* Edward Elgar Publishing

DSGE models are the main tool for analysing various questions in problems of monetary, business cycle theory and fiscal policy problems, growth and other fields in international macroeconomics and macroeconomics. Many macroeconomic publications use the DSGE framework. A consensus has been reached on the methodology for using such kind of model. The resolution of DSGE models remains an area of ongoing interest. This paper provides an overview of the available solution techniques. Linear approximation methods and perturbation methods have been explored in detail. Solving strategies such as the eigenvalue auto-decomposition of Blanchard and Kahn (1980) or the method of indefinite coefficients are explained. A Bayesian estimate is drawn shortly. The evaluation methods are briefly described. Finally, the paper provides some useful resources for practical implementation.

**Model-Based Globally-Consistent Risk Assessment** Cambridge University Press

Dynamic stochastic general equilibrium (DSGE) models have become one of the workhorses of modern macroeconomics and are extensively used for academic research as well as forecasting and policy analysis at central banks. This

book introduces readers to state-of-the-art computational techniques used in the Bayesian analysis of DSGE models. The book covers Markov chain Monte Carlo techniques for linearized DSGE models, novel sequential Monte Carlo methods that can be used for parameter inference, and the estimation of nonlinear DSGE models based on particle filter approximations of the likelihood function. The theoretical foundations of the algorithms are discussed in depth, and detailed empirical applications and numerical illustrations are provided. The book also gives invaluable advice on how to tailor these algorithms to specific applications and assess the accuracy and reliability of the computations. Bayesian Estimation of DSGE Models is essential reading for graduate students, academic researchers, and practitioners at policy institutions.

*Macroeconomic Outcomes in Disaster-Prone Countries* Academic Press

This volume of *Advances in Econometrics* contains articles that examine key topics in the modeling and estimation of dynamic stochastic general equilibrium (DSGE) models. Because DSGE models combine micro- and macroeconomic theory with formal econometric modeling and inference, over the past decade they have become an established framework for analyzing **Efficient Perturbation Methods for Solving Regime-Switching DSGE Models** Princeton University Press

This paper shows that perturbation methods can be applied to a DSGE model with incomplete markets and a finite but arbitrarily large number of heterogeneous agents. We develop a simple but general solution technique that handles many state and choice variables for each agent and thus has an

extremely high-dimensional state space. The method is based on perturbations around a point at which the solution is known. The novel idea is to exploit the symmetry of the problem to overcome the curse of dimensionality. We use the analysis to demonstrate the impact of heterogeneity on macroeconomic quantities and the pricing of risk. Furthermore, we set our technique apart from standard methods used in the literature.

DSGE Models in Macroeconomics Oxford University Press

The third volume of edited papers from the Tenth World Congress of the Econometric Society 2010.

**Finance India** Springer Nature

This book summarizes the evolution of modern macroeconomics (New Consensus Macroeconomics, NCM) and proposes a new approach to theoretical and empirical analysis, which is based on a recently developed dynamic stochastic general equilibrium (DSGE) model.

Dynamic macroeconomic analysis in emerging market economies is challenging, and of growing importance in the global economy, where emerging markets are becoming more and more influential. Clearly, a deeper understanding of the inner workings of emerging economies, particularly with respect to their socioeconomic structure and the urbanization process, is needed. The book's extends the NCM/DSGE model to better account for significant economic and social features in emerging market economies. In particular, household heterogeneities and social stratification are explicitly incorporated into the framework proposed here, substantially enhancing the comprehensiveness of the model economy, and allowing it to better account for underlying social structure in

emerging economies. Furthermore, financial and housing markets have not been considered sufficiently in either the advanced or emerging economy literature, an oversight this book remedies. As such, it makes an original and valuable contribution to the field, and a direction for future research.

**Advances in Economics and Econometrics: Volume 3, Econometrics** MIT Press

We introduce a nonlinear infinite moving average as an alternative to the standard state-space policy function for solving nonlinear DSGE models.

Perturbation of the nonlinear moving average policy function provides a direct mapping from a history of innovations to endogenous variables, decomposes the contributions from individual orders of uncertainty and nonlinearity, and enables familiar impulse response analysis in nonlinear settings. When the linear approximation is saddle stable and free of unit roots, higher order terms are likewise saddle stable and first order corrections for uncertainty are zero. We derive the third order approximation explicitly and examine the accuracy of the method using Euler equation tests. --

Perturbation ; nonlinear impulse response ; DSGE ; solution methods

Introduction to Quantitative

Macroeconomics Using Julia MIT Press

Handbook of Computational Economics: Heterogeneous Agent Modeling, Volume Four, focuses on heterogeneous agent models, emphasizing recent advances in macroeconomics (including DSGE), finance, empirical validation and experiments, networks and related applications. Capturing the advances made since the publication of Volume Two (Tesfatsion & Judd, 2006), it provides high-level literature with sections devoted to Macroeconomics,

Finance, Empirical Validation and Experiments, Networks, and other applications, including Innovation Diffusion in Heterogeneous Populations, Market Design and Electricity Markets, and a final section on Perspectives on Heterogeneity. Helps readers fully understand the dynamic properties of realistically rendered economic systems Emphasizes detailed specifications of structural conditions, institutional arrangements and behavioral dispositions Provides broad assessments that can lead researchers to recognize new synergies and opportunities

*The Oxford Handbook of Computational Economics and Finance* OUP Oxford

Handbook of Macroeconomics Volumes 2A and 2B surveys major advances in macroeconomic scholarship since the publication of Volume 1 (1999), carefully distinguishing between empirical, theoretical, methodological, and policy issues, including fiscal, monetary, and regulatory policies to deal with crises, unemployment, and economic growth. As this volume shows, macroeconomics has undergone a profound change since the publication of the last volume, due in no small part to the questions thrust into the spotlight by the worldwide financial crisis of 2008. With contributions from the world's leading macroeconomists, its reevaluation of macroeconomic scholarship and assessment of its future constitute an investment worth making. Serves a double role as a textbook for macroeconomics courses and as a gateway for students to the latest research Acts as a one-of-a-kind resource as no major collections of macroeconomic essays have been published in the last decade Builds upon Volume 1 by using its section headings to illustrate just how far macroeconomic thought has evolved

**Exact likelihood computation for nonlinear DSGE models with heteroskedastic innovations** MIT Press

This is an insightful survey of approaches to computational analysis of economics and finance.

Handbook of Research Methods and Applications in Empirical Macroeconomics Elsevier

Handbook of Computational Economics summarizes recent advances in economic thought, revealing some of the potential offered by modern computational methods. With computational power increasing in hardware and algorithms, many economists are closing the gap between economic practice and the frontiers of computational mathematics. In their efforts to accelerate the incorporation of computational power into mainstream research, contributors to this volume update the improvements in algorithms that have sharpened econometric tools, solution methods for dynamic optimization and equilibrium models, and applications to public finance, macroeconomics, and auctions. They also cover the switch to massive parallelism in the creation of more powerful computers, with advances in the development of high-power and high-throughput computing. Much more can be done to expand the value of computational modeling in economics. In conjunction with volume one (1996) and volume two (2006), this volume offers a remarkable picture of the recent development of economics as a science as well as an exciting preview of its future potential. Samples different styles and approaches, reflecting the breadth of computational economics as practiced today Focuses on problems with few well-developed solutions in the literature

of other disciplines Emphasizes the potential for increasing the value of computational modeling in economics

**Solving an Incomplete Markets Model with a Large Cross-Section of Agents** Princeton University Press

This paper compares different solution methods for computing the equilibrium of dynamic stochastic general equilibrium (DSGE) models with rare disasters along the line of those proposed by Rietz (1988), Barro (2006), Gabaix (2012), and Gourio (2012). DSGE models with rare disasters require solution methods that can handle the large non-linearities triggered by low-probability, high-impact events with sufficient accuracy and speed. We solve a standard New Keynesian model with Epstein-Zin preferences and time-varying disaster risk with perturbation, Taylor projection, and Smolyak collocation. Our main finding is that Taylor projection delivers the best accuracy/speed tradeoff among the tested solutions. We also document that even third-order perturbations may generate solutions that suffer from accuracy problems and that Smolyak collocation can be costly in terms of run time and memory requirements.

*Bayesian Analysis of DSGE Models*

*Solving DSGE Models - When Local Approximations Fail* This paper studies the effect of persistent growth risks on the solution accuracy of dynamic stochastic general equilibrium models. We compare the reliability of perturbation and projection based solution methods for various model economies. We find that a perturbation based solution method does not suffice whenever the economy is exposed to risks with long-lasting effects. Besides slightly misstating macroeconomic moments the perturbation based

solution strongly understates the mean risk-free rate and the wealth-consumption ratio. Further, we identify parameters driving the approximation error and compare different degrees of approximation. We show that projection methods do a better job at approximating asset pricing and welfare quantities than perturbation methods even for low order polynomials. Efficient Perturbation Methods for Solving Regime-Switching DSGE Models In an environment where economic structures break, variances change, distributions shift, conventional policies weaken and past events tend to reoccur, economic agents have to form expectations over different regimes. This makes the regime-switching dynamic stochastic general equilibrium (RS-DSGE) model the natural framework for analyzing the dynamics of macroeconomic variables. We present efficient solution methods for solving this class of models, allowing for the transition probabilities to be endogenous and for agents to react to anticipated events. The solution algorithms derived use a perturbation strategy which, unlike what has been proposed in the literature, does not rely on the partitioning of the switching parameters. These algorithms are all implemented in RISE, a flexible object-oriented toolbox that can easily integrate alternative solution methods. We show that our algorithms replicate various examples found in the literature. Among those is a switching RBC model for which we present a third-order perturbation solution. Solving DSGE Models with a Nonlinear Moving Average We introduce a nonlinear infinite moving average as an alternative to the standard state-space policy function for solving nonlinear DSGE models. Perturbation of the nonlinear moving



average policy function provides a direct mapping from a history of innovations to endogenous variables, decomposes the contributions from individual orders of uncertainty and nonlinearity, and enables familiar impulse response analysis in nonlinear settings. When the linear approximation is saddle stable and free of unit roots, higher order terms are likewise saddle stable and first order corrections for uncertainty are zero. We derive the third order approximation explicitly and examine the accuracy of the method using Euler equation tests. -- Perturbation ; nonlinear impulse response ; DSGE ; solution methodsEfficient Perturbation Methods for Solving Regime-switching DSGE ModelsFifth-Order Perturbation Solution to DSGE ModelsThis paper derives a fifth-order perturbation solution to DSGE models. The paper develops a new notation that reduces the notational complexity of high-order solutions and yields a faster code. The new notation consists of new matrix forms of high-order multivariate chain rules and a new representation of the model as a function of one vector variable. The algorithm that implements the new notation is between 3 to 55 times faster than Dynare , depending on model size and solution order.Perturbation Methods for Markov-switching DSGE ModelsMarkov-switching DSGE (MSDSGE) modeling has become a growing body of literature on economic and policy issues related to structural shifts. This paper develops a general perturbation methodology for constructing high-order approximations to the solutions of MSDSGE models. Our new method, called "the partition perturbation method," partitions the Markov-switching parameter space to keep a maximum number of time-

varying parameters from perturbation. For this method to work in practice, we show how to reduce the potentially intractable problem of solving MSDSGE models to the manageable problem of solving a system of quadratic polynomial equations. We propose to use the theory of Gröbner bases for solving such a quadratic system. This approach allows us to first obtain all the solutions and then determine how many of them are stable. We illustrate the tractability of our methodology through two examples.A Comparison of Numerical Methods for the Solution of Continuous-time DSGE ModelsIntroduction to Quantitative Macroeconomics Using Julia Bayesian econometric methods have enjoyed an increase in popularity in recent years. Econometricians, empirical economists, and policymakers are increasingly making use of Bayesian methods. This handbook is a single source for researchers and policymakers wanting to learn about Bayesian methods in specialized fields, and for graduate students seeking to make the final step from textbook learning to the research frontier. It contains contributions by leading Bayesians on the latest developments in their specific fields of expertise. The volume provides broad coverage of the application of Bayesian econometrics in the major fields of economics and related disciplines, including macroeconomics, microeconomics, finance, and marketing. It reviews the state of the art in Bayesian econometric methodology, with chapters on posterior simulation and Markov chain Monte Carlo methods, Bayesian nonparametric techniques, and the specialized tools used by Bayesian time series econometricians such as state space models and particle filtering. It also includes chapters on Bayesian

principles and methodology.

Fifth-Order Perturbation Solution to DSGE Models Elsevier

A unified, comprehensive, and up-to-date introduction to the analytical and numerical tools for solving dynamic economic problems. This book offers a unified, comprehensive, and up-to-date treatment of analytical and numerical tools for solving dynamic economic problems. The focus is on introducing recursive methods—an important part of every economist's set of tools—and readers will learn to apply recursive methods to a variety of dynamic economic problems. The book is notable for its combination of theoretical foundations and numerical methods. Each topic is first described in theoretical terms, with explicit definitions and rigorous proofs; numerical methods and computer codes to implement these methods follow. Drawing on the latest research, the book covers such cutting-edge topics as asset price bubbles, recursive utility, robust control, policy analysis in dynamic New Keynesian models with the zero lower bound on interest rates, and Bayesian estimation of dynamic stochastic general equilibrium (DSGE) models. The book first introduces the theory of dynamical systems and numerical methods for solving dynamical systems, and then discusses the theory and applications of dynamic optimization. The book goes on to treat equilibrium analysis, covering a variety of core macroeconomic models, and such additional topics as recursive utility (increasingly used in finance and macroeconomics), dynamic games, and recursive contracts. The book introduces Dynare, a widely used software platform for handling a range of economic models; readers will learn to use Dynare for numerically solving DSGE models and

performing Bayesian estimation of DSGE models. Mathematical appendixes present all the necessary mathematical concepts and results. Matlab codes used to solve examples are indexed and downloadable from the book's website. A solutions manual for students is available for sale from the MIT Press; a downloadable instructor's manual is available to qualified instructors.

Справочное руководство по макроэкономике. В 5 книгах. Книга 2. Методология в макроэкономике Oxford University Press

This is the third of three volumes containing edited versions of papers and commentaries presented at invited symposium sessions of the Tenth World Congress of the Econometric Society, held in Shanghai in August 2010. The papers summarize and interpret key developments in economics and econometrics, and they discuss future directions for a wide variety of topics, covering both theory and application. Written by the leading specialists in their fields, these volumes provide a unique, accessible survey of progress on the discipline. The first volume primarily addresses economic theory, with specific focuses on nonstandard markets, contracts, decision theory, communication and organizations, epistemics and calibration, and patents. Computing DSGE Models with Recursive Preferences Litres

Using a dynamic stochastic general equilibrium model, we study the channels through which natural disaster shocks affect macroeconomic outcomes and welfare in disaster-prone countries. We solve the model using Taylor projection, a solution method that is shown to deal effectively with high-impact weather shocks calibrated in accordance to empirical evidence. We



find large and persistent effects of weather shocks that significantly impact the income convergence path of disaster-prone countries. Relative to non-disaster-prone countries, on average, these shocks cause a welfare loss equivalent to a permanent fall in consumption of 1.6 percent. Welfare gains to countries that self-finance

investments in resilient public infrastructure are found to be negligible, and international aid has to be sizable to achieve significant welfare gains. In addition, it is more cost-effective for donors to contribute to the financing of resilience before the realization of disasters, rather than disbursing aid after their realization.

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