Bayesian Estimation Of Dsge Models The Econometric And Tinbergen Institutes Lectures

We review the current state of the estimation of DSGE models. After introducing a general framework for dealing with DSGE models, the state-space representation, we discuss how to evaluate moments or the likelihood function implied by such a structure. We discuss, in varying degrees of detail, recent advances in the field, such as the tempered particle filter, approximated Bayesian computation, the Hamiltonian Monte Carlo, variational inference, and machine learning, methods that show much promise, but that have not been fully explored yet by the DSGE community. We conclude by outlining three future challenges for this line of research.
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Dynamic Stochastic General Equilibrium (DSGE) models have become a standard tool in various fields of economics. This type of models has a superior theoretical foundation when compared to the Keynesian models which are traditionally used for policy analysis and forecasting. Although a lot has been done to improve the empirical properties of DSGE models, there is still a need for further research in this field. In this book, the author first considers a closed economy general equilibrium framework to empirically validate the alternative mechanisms for introducing nominal rigidities. As the comparison is done in the context of the Euro area aggregate data, the results provide guidance to researchers dealing with estimation of Euro area DSGE models in general. In the second part of the book, a coherent economic and statistical framework that approximates the structure of the EMU and explicitly accounts for the historical monetary regime change is presented. In such a framework the disaggregate information on the Euro area can be utilized, so that one can explain the area-wide aggregates, and also examine the cross-region linkages.
This paper develops a small open economy model where entrepreneurs partially finance investment using foreign currency denominated debt subject to a risk premium above and beyond international interest rates. We use Bayesian estimation techniques to evaluate the importance of balance sheet vulnerabilities combined with the presence of the financial accelerator for emerging market countries. Using Korean data, we obtain an estimate for the external risk premium, indicating the importance of the financial accelerator and potential balance sheet vulnerabilities for macroeconomic fluctuations. Furthermore, our estimates of the Taylor rule imply a strong preference to smooth both exchange rate and interest rate fluctuations.
This paper addresses the growing gulf between traditional macroeconometrics and the increasingly dominant preference among macroeconomists to use DSGE models and to estimate them using Bayesian estimation with strong priors but not to test them as they are likely to fail conventional statistical tests. This is in conflict with the high scientific ideals with which DSGE models were first invested in their aim of finding true models of the macroeconomy. As macro models are in reality only approximate representations of the economy, we argue that a pseudo-true inferential framework should be used to provide a measure of the robustness of DSGE models.
This paper proposes a novel way of formulating priors for estimating economic models. System priors are priors about the model's features and behavior as a system, such as the sacrifice ratio or the maximum duration of response of inflation to a particular shock, for instance. System priors represent a very transparent and economically meaningful way of formulating priors about parameters, without the unintended consequences of independent priors about individual parameters. System priors may complement or also substitute for independent marginal priors. The new philosophy of formulating priors is motivated, explained and illustrated using a structural model for monetary policy.
We survey Bayesian methods for estimating dynamic stochastic general equilibrium (DSGE) models in this article. We focus on New Keynesian (NK)DSGE models because of the interest shown in this class of models by economists in academic and policy-making institutions. This interest stems from the ability of this class of DSGE model to transmit real, nominal, and fiscal and monetary policy shocks into endogenous fluctuations at business cycle frequencies. Intuition about these propagation mechanisms is developed by reviewing the structure of a canonical NKDSGE model. Estimation and evaluation of the NKDSGE model rests on being able to detrend its optimality and equilibrium conditions, to construct a linear approximation of the model, to solve for its linear approximate decision rules, and to map from this solution into a state space model to generate Kalman filter projections. The likelihood of the linear approximate NKDSGE model is based on these projections. The projections and likelihood are useful inputs into the Metropolis-Hastings Markov chain Monte Carlo simulator that we employ to produce Bayesian estimates of the NKDSGE model. We discuss an algorithm that implements this simulator. This algorithm involves choosing priors of the NKDSGE model parameters and fixing initial conditions to start the simulator. The output of the simulator is posterior estimates of two NKDSGE models, which are summarized and compared to results in the existing literature. Given the posterior distributions, the NKDSGE models are evaluated with tools that determine which is most favored by the data. We also give a short history of DSGE model estimation as well as pointing to issues that are at the frontier of this research.
Resumen Esta tesis presenta tres diferentes experimentos de política utilizando estimaciones Bayesianas de modelos DSGE. En la primera parte, se quiere demostrar que una política fiscal contracíclica es un instrumento importante para la estabilidad macroeconómica. Este resultado es robusto a diferentes controles. En la segunda parte, se demuestra las variaciones de las estimaciones de los parámetros estructurales según la descomposición ciclo-tendencia, si en uno o en dos estadios. Resulta que con un procedimiento a dos estadios la volatilidad del PIB es explicada mayormente por shocks nominales, mientras que con un procedimiento a un estadio por un shock a la inversión. Se argumenta que el

procedimiento a un estadio proporciona una estructura probabilística más coherente. La tercera parte de la tesis propone una manera de estimar los parámetros estructurales utilizando la información procedente de distintos filtros. Mientras que con un tipo de estimación con un único filtro el dinero tiene poca influencia en las fluctuaciones de medio plazo, con un sistema de múltiples filtros el dinero tiene un papel importante en la transmisión de los shocks. Abstract This thesis examines three different policy experiments using Bayesian estimates of DSGE models. First, we show that countercyclical fiscal policies are important to smooth fluctuations and that this is true regardless of how we specify the fiscal rule and several details of the model. Second, we show that the sources of output volatility obtained from a cyclical DSGE model crucially depend on whether estimation is done sequentially or jointly. In fact, while with a two step procedure, where the trend is first removed, nominal shocks drive output volatility, investment shocks dominate when structural and trend parameters are estimated jointly. Finally, we examine the role of money for business cycle fluctuations with a single and a multiple filtering approach, where information provided by different filters is joint.
When estimating DSGE models, the number of observable economic variables is usually kept small, and it is conveniently assumed that DSGE model variables are perfectly measured by a single data series. Building upon Boivin and Giannoni (2006), we relax these two assumptions and estimate a fairly simple monetary DSGE model on a richer data set. Using post-1983 U.S.data on real output, inflation, nominal interest rates, measures of inverse money velocity, and a large panel of informational series, we compare the data-rich DSGE model with the regular - few observables, perfect measurement - DSGE model in terms of deep parameter estimates, propagation of monetary policy and technology shocks and sources of business cycle fluctuations. We document that the data-rich DSGE model generates a higher implied duration of Calvo price contracts and a lower slope of the New Keynesian Phillips curve. To reduce the computational costs of the likelihood-based estimation, we employed a novel speedup as in Jungbacker and Koopman (2008) and achieved the time savings of 60 percent.
The 'New Keynesian' model assumes that prices and wages are in an extreme 'sticky'pattern. In this model, the ssumption that a lagged indexation scheme increases the persistence of inflation is in widespread used; however, in reality, this ad hoc indexation setup is inconsistent with the real data. Moreover, there is extensive evidence on micro price data indicates that heterogeneity in price stickiness is a commonly found feature of price setting throughout the Euro area. Therefore, this thesis aims at incorporating this micro price evidence in an elaborated New Keynesian Dynamic Stochastic General Equilibrium (DSGE) model by using a Generalised- Taylor-Economy (GTE) and Generalised-Calvo (GC) price settings. This thesis first presents the models, which are an extension of Smets-Wouters (SW) model (2003) which replaces Calvo with indexation price setting with heterogeneous price settings. In these new price settings, the micro evidence of heterogeneous price stickiness is directly emerged into macro DSGE models. The findings suggest that heterogeneous price stickiness can generate long-lived inflation and output persistence. Indirect inference is then used to evaluate the DSGE models of the French economy under different price settings. The results of the testing show that all models with differentprice settings are comprehensively rejected. The models are then estimated with Bayesian techniques as SW (2003) by using seven key macroeconomic observables. The results show that the GC model has the best performance. The rankings of the different price setting models are also proven to be robust to different priors and observables. Indirect inference evaluations are then conducted based on Bayesian estimated models, and all models are rejected. Indirect inference is then used as an estimation method. The testing results are improved on all models. The GC model is still considered to be the best performance model among all of the different price setting models.
Bayesian Estimation of DSGE ModelsPrprinceton University Press
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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.
This dissertation consists of five chapters addressing analytically and empirically U.S. Postwar business cycle fluctuations. Markov Switching models and Bayesian estimation methods are used to investigate United States macroeconomic dynamics in the last 60 years. Chapter 1 introduces the structure of this dissertation. Chapter 2 proposes a dynamic stochastic general equilibrium (DSGE) model with Markov Switching and heteroskedastic shocks to examine the role of agents' beliefs separately from changes in monetary policy in explaining inflation fluctuations. Bayesian analysis is conducted with Markov Switching to support regime switches in the private sector, in the implementation of monetary policy and in the volatility of shocks in the U.S. Postwar economy, which are related to the "Great Inflation", the "Great Moderation" and the 2008 financial crisis. A counterfacutal analysis found that if agents maintained a weak response to macroeconomic dynamics over time, there would be lower inflation during the "Great Inflation". In addition, irrespectively to monetary policy regimes, supply shocks are the main driver of inflation fluctuations, while demand shocks are the main source of changes in the output gap. However, when agents maintain a higher risk aversion towards consumption with a higher slope in the Phillips curve, demand shocks also play a role in driving inflation, even though supply shocks are still the main driver of inflation. Chapter 3 emphasizes on the monetary policy with an investigation on

the assumption that policymakers commit to a Taylor rule, using a time-varying inflation-unemployment dynamic model on U.S. economy. This chapter is based on the conjecture that potential policymakers' misperception may be originated from unobserved deviations of unemployment from its natural rate. Five processes are proposed for policymakers' belief under commitment to inflation and unemployment and compare them with a baseline autoregressive process without commitment. The models are estimated using Bayesian techniques. Empirical results are as follows: First, policymakers' belief is very persistent even when it commits to a Taylor-type policy rule. Second, the run-up of U.S. inflation around 1980 can be mostly attributed to policymakers' misperception while the peak surge of inflation in 1974 is possibly a result of non-policy shocks. Third, models with commitment dominate models without commitment, especially in periods of large oscillations in inflation. In particular, when policymakers are committed to respond to a Taylor-type policy rule, the average loss function is considerably reduced over time, thus effectively lessening potential misperceptions. Chapter 4 introduces a simple version of adaptive expectation to a dynamic stochastic general equilibrium (DSGE) model to evaluate the goodness of fitness and forecasting performance on U.S. macroeconomic indicators. Analytical maximum likelihood estimation results represent a DSGE model with adaptive expectation outperforms a DSGE model with rational expectation. In addition to providing a better fit of inflation and output gap in the U.S. Postwar macro economy, a DSGE model with adaptive expectation also leads to redundant lagged inflation in fitting inflation dynamics. Chapter 5 concludes and proposes future extension.

We propose a method for solving and estimating linear rational expectations models that exhibit indeterminacy and we provide step-by-step guidelines for implementing this method in the Matlab-based packages Dynare and Gensys. Our method redefines a subset of expectational errors as new fundamentals. This redefinition allows us to treat indeterminate models as determinate and to apply standard solution algorithms. We provide a selection method, based on Bayesian model comparison, to decide which errors to pick as fundamental and we present simulation results to show how our procedure works in practice.

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Abstract This thesis makes three main contributions to the literature on Dynamic Stochastic General Equilibrium (DSGE) models in Macroeconomics. As no previous studies have studied the Chinese economy from the perspective of DSGE, the first contribution of this thesis is estimating a DSGE model for China through a Bayesian approach using the Chinese quarterly post-economic reform data representing the main macro-economic time series 1978.Q1-2007.Q4. Second, this thesis adopts a new method of evaluating macro-economic models in its evaluation of the estimated DSGE model for China. Rather than the classical methods used to evaluate a macro-economic model such as the Maximum Likelihood method, the method of Indirect Inference is used to test the DSGE model. This method differs from other methods in its adoption of a VAR as the auxiliary model that mimics reality. A hybrid model is adopted to improve the ability of the DSGE model to replicate real world results and compared to the original New Keynesian version of the DSGE model developed by Smets and Wouters. Third, considering the restrictions that the prior distribution imposed on the estimated parameters of the model in the Bayesian estimation, the estimation method of Indirect Inference is used in the last chapter of this thesis and compared with the Bayesian estimation. The results of the Bayesian estimation are in agreement with most of the existing literature on DSGE models. However, the results of Indirect Inference testing suggest that the adopted DSGE model does not closely resemble the real data, with a Hybrid model with 50% weight on the NK part performing significantly better. Indirect Inference estimation produces the same results and provides a better estimation of the model.

The authors show that in weakly identified models (1) the posterior mode will not be a consistent estimator of the true parameter vector, (2) the posterior distribution will not be Gaussian even asymptotically, and (3) Bayesian credible sets and frequentist confidence sets will not coincide asymptotically. This means that Bayesian DSGE estimation should not be interpreted merely as a convenient device for obtaining asymptotically valid point estimates and confidence sets from the posterior distribution. As an alternative, the authors develop a new class of frequentist confidence sets for structural DSGE model parameters that remains asymptotically valid regardless of the strength of the identification. The proposed set correctly reflects the uncertainty about the structural parameters even when the likelihood is flat, it protects the researcher from spurious inference, and it is asymptotically invariant to the prior in the case of weak identification.

Koop, Pesaran and Smith (2011) suggest a simple diagnostic indicator for the Bayesian estimation of the parameters of a DSGE model. They show that, if a parameter is well identified, the precision of the posterior should improve as the (artificial) data size T increases, and the indicator checks the speed at which precision improves. It does not require any additional programming; a researcher just needs to generate artificial data and estimate the model with different T. Applying this to Smets and Wouters?(2007) medium size US model, we find that while exogenous shock processes are well identified, most of the parameters in the structural equations are not. -- Bayesian Estimation ; Dynamic stochastic general equilibrium models ; Identification

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.

This paper investigates financial frictions in US postwar data to understand the interaction between the real business cycle and the credit market. A Bayesian estimation technique is used to estimate a large Vector Autoregression and New Keynesian models demonstrating how financial shocks can have a large and sluggish impact on the economy. I identify the default risk and the maturity mismatch channels of monetary policy transmission; I further employ a generalized-IRF to establish countercyclicality of risk spreads; and I show that the maturity mismatch shocks produce a stronger impact than the default risk shocks.

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 analy

This comprehensive Handbook presents the current state of art in the theory and methodology of macroeconomic data analysis. It is intended as a reference for graduate students and researchers interested in exploring new methodologies, but can also be employed as a graduate text. The Handbook concentrates on the most important issues, models and techniques for research in

macroeconomics, and highlights the core methodologies and their empirical application in an accessible manner. Each chapter is largely self-contained, whilst the comprehensive introduction provides an overview of the key statistical concepts and methods. All of the chapters include the essential references for each topic and provide a sound guide for further reading. Topics covered include unit roots, non-linearities and structural breaks, time aggregation, forecasting, the Kalman filter, generalised method of moments, maximum likelihood and Bayesian estimation, vector autoregressive, dynamic stochastic general equilibrium and dynamic panel models. Presenting the most important models and techniques for empirical research, this Handbook will appeal to students, researchers and academics working in empirical macro and econometrics.

This is a Chinese translation of "Rethinking Macro Policy II" (SDN/13/03). This note explores how the economic thinking about macroeconomic management has evolved since the crisis began. It discusses developments in monetary policy, including unconventional measures; the challenges associated with increased public debt; and the policy potential, risks, and institutional challenges associated with new macroprudential measures. Rationale: The note contributes to the ongoing debate on several aspects of macroeconomic policy. It follows up on the earlier “Rethinking” paper, refining the analysis in light of the events of the past two years. Given the relatively fluid state of the debate (e.g., recent challenges to central bank independence), it is useful to highlight that while many of the tenets of the pre-crisis consensus have been challenged, others (such as the desirability of central bank independence) remain valid.

In this paper, I review the literature on the formulation and estimation of dynamic stochastic general equilibrium (DSGE) models with a special emphasis on Bayesian methods. First, I discuss the evolution of DSGE models over the last couple of decades. Second, I explain why the profession has decided to estimate these models using Bayesian methods. Third, I briefly introduce some of the techniques required to compute and estimate these models. Fourth, I illustrate the techniques under consideration by estimating a benchmark DSGE model with real and nominal rigidities. I conclude by offering some pointers for future research.

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A unified and comprehensive introduction to the analytical and numerical tools for solving dynamic economic problems; substantially revised for the second edition. 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. This second edition has been substantially updated. Responding to renewed interest in modeling with multiple equilibria, it incorporates new material on this topic throughout. It offers an entirely new chapter on deterministic nonlinear systems, and provides new material on such topics as linear planar systems, chaos, bifurcations, indeterminacy and sunspot solutions, pruning nonlinear solutions, the bandit problem, rational inattention models, bequests, self-fulfilling prophecies, the cyclical behavior of unemployment and vacancies, and the long-run risk model. The exposition of each chapter has been revised and improved, and many new figures, Matlab codes, and exercises have been added. A student solutions manual can be purchased separately.

In this thesis, I have considered two questions related to transition economies in Central Europe. The first is why some countries converge toward the Euro area accession criteria, while others are still far from the stability criteria. The second question is how did the structure of the economy and the monetary policy change during the transition. I answer to these questions by analysing dynamic stochastic general equilibrium (DSGE) models using Bayesian econometric methods. I have extended the usual estimation techniques in order to consider structural changes in the economy. In the first chapter, I introduce the general methodology of Bayesian estimation of linear DSGE models. In the second chapter, I have built a DSGE model incorporating some features of the transition economies and have estimated it using the Bayesian method. Finally, in the third chapter, I have estimated a model considering a structural change date in parameters and heteroskedasticity of shocks.

Thesis (M.A.) from the year 2010 in the subject Business economics - Banking, Stock Exchanges, Insurance, Accounting, grade: A-, Central European University Budapest, language: English, abstract: Using of developments of the last decade in Bayesian estimation, I estimate a small open economy Dynamic Stochastic General Equ ilibr ium (DSGE) model fo r Turkey. The thesis explicitly accounts for a monetar y regime change fro m an exchange rate targeting to an exp licit inflation targeting with a flexible exchange rate. In both regimes, I investigate the behavior of the monetary authority and the main driving forces of business cycles of key macro economy variables of the Turkish economy. My results can be summarized as follows. Monetary policy focused on the stabilizing of the nominal exchange rate in the exchange rate targeting regime. But, it is mainly concerned with the price stability in the inflation targeting reg ime. Monetary policy shocks were the main sources of the fluctuations under both regimes. However, the foreign output shock in the first regime and the real exchange rate shock in the second regime appeared as the additional sources of the fluctuations in the business cycles. The Central Bank of Tur key managed to neutralize inflatio nary sho cks and achieved stability in output and consumption after the regime change. Keywords: Turkey, Bayesian estimation, DSGE models, regime change

My dissertation has four chapters. I use dynamic stochastic general equilibrium (DSGE) models to study the welfare implications of exchange rate, monetary, and fiscal policies in de facto dollarized economies. Dollarization is a common phenomenon in emerging economies. In many of them economic agents hold liabilities in foreign currency while most income is earned in domestic currency. Thus, a sudden depreciation of the domestic currency may cause significant adverse effects on domestic agents' wealth and welfare. That is why governments try to design and implement macroeconomic policies that help reduce these adverse effects. My work aims at contributing to the design and implementation of these policies. In the first chapter, I study alternative exchange rate regimes in a dollarized economy. I develop a DSGE model and pursue Bayesian estimation using data from Singapore. The main conclusion is that the flexible exchange rate regime is better than the fixed exchange rate. In the second chapter, I work on an extension of my first chapter by introducing nontradable goods, which allows me to study a broader set of exchange rate regimes in a dollarized economy. I develop a DSGE model and pursue Bayesian estimation using data from Peru. The main conclusion is that a policy that pegs the domestic currency price of exports is better than a flexible exchange rate regime that targets the

consumer price index, which in turn is better than the fixed exchange rate. The third chapter studies the optimal fiscal rule for a dollarized economy. Using a DSGE model with endogenous dollarization, I obtain that an optimal fiscal rule should take into account deviations (from their steady state values) of the level of government debt, government spending, and inflation. The fourth chapter characterizes the optimal exchange rate policy in a dollarized economy using a method developed by Devereux and Sutherland (2007, 2008). The method allows me to use a DSGE model in order to compute the optimal currency composition of the portfolio of (foreign) liabilities in the long-run equilibrium and its dynamics. The main finding is that the flexible exchange rate is better than the fixed rate.

"This paper estimates the parameters of a stylized dynamic stochastic general equilibrium model using maximum likelihood and Bayesian methods, paying special attention to the issue of weak parameter identification. Given the model and the available data, the posterior estimates of the weakly identified parameters are very sensitive to the choice of priors. We provide a set of tools to diagnose weak identification, which include surface plots of the log-likelihood as a function of two parameters, heat plots of the log-likelihood as a function of three parameters, Monte Carlo simulations using artificial data, and Bayesian estimation using three sets of priors. We find that the policy coefficients and the parameter governing the elasticity of labor supply are weakly identified by the data, and posterior predictive distributions remind us that DSGE models may make poor forecasts even when they fit the data well. Although parameter identification is model- and data-specific, the lack of identification of some key structural parameters in a small-scale DSGE model such as the one we examine should raise a red flag to researchers trying to estimate--and draw valid inferences from--large-scale models featuring many more parameters"--Federal Reserve Board web site.

Two approaches are considered to incorporate judgment in DSGE models. First, Bayesian estimation indirectly imposes judgment via priors on model parameters, which are then mapped into a judgmental interest rate decision. Standard priors are shown to be associated with highly unrealistic judgmental decisions. Second, judgmental interest rate decisions are directly provided by the decision maker, and incorporated into a formal statistical decision rule using frequentist procedures. When the observed interest rates are interpreted as judgmental decisions, they are found to be consistent with DSGE models for long stretches of time, but excessively tight in the 1980s and late 1990s and excessively loose in the late 1970s and early 2000s.

In this paper we adopt the Hamiltonian Monte Carlo (HMC) estimator for DSGE models by implementing it into a state-of-the-art, freely available high-performance software package. We estimate a small scale textbook New-Keynesian model and the Smets-Wouters model on US data. Our results and sampling diagnostics con firm the parameter estimates available in existing literature. In addition we combine the HMC framework with the Sequential Monte Carlo (SMC) algorithm which permits the estimation of DSGE models with ill-behaved posterior densities.