contributions to economic analysis

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Editors

Using Dynamic General Equilibrium Models for Policy Analysis

North-Holland

USING DYNAMIC GENERAL EQUILIBRIUM MODELS FOR POLICY ANALYSIS

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INTRODUCTION TO THE SERIES

This series consists of a number of hitherto unpublished studies, which are introduced by the editors in the belief that they represent fresh contributions to economic science.

The term 'economic analysis' as used in the title of the series has been adopted because it covers both the activities of the theoretical economist and the research worker.

Although the analytical methods used by the various contributors are not the same, they are nevertheless conditioned by the common origin of their studies, namely theoretical problems encountered in practical research. Since for this reason, business cycle research and national accounting, research work on behalf of economic policy, and problems of planning are the main sources of the subjects dealt with, they necessarily determine the manner of approach adopted by the authors. Their methods tend to be 'practical' in the sense of not being too far remote from application to actual economic conditions. In addition they are quantitative.

It is the hope of the editors that the publication of these studies will help to stimulate the exchange of scientific information and to reinforce international cooperation in the field of economics.

The Editors

Preface

This volume contains a selection of papers presented at the international conference "Using Dynamic General Equilibrium Models for Policy Analysis", held at Gl. Avernaes, Denmark, June 1998. The conference was jointly organized by the MobiDK Modeling Group within the Danish Ministry of Trade and Industry, the Computable General Equilibrium Modeling Group of Statistics Denmark and the Netherlands Bureau for Economic Policy Analysis. The conference brought together more than 100 academics and policy analysts from within government.

The conference was organized to reflect the current art of *applying* dynamic general equilibrium models. If economic theory is rigorously applied, can it provide useful insights into topical policy issues? We believe that the conference demonstrated that economic theory, computers and dynamic economic models were able to provide useful insights.

The selection of papers from the original conference submissions reflected three criteria: rigor, relevance, and real-world applications. In editing the book we have, therefore, had a broad readership in mind: academics, civil servants and students of economics should find the book useful.

This book is the outcome of a major effort by many people. Our principal debt is to the contributors and the conference participants. All submitted papers have been subject to a rigorous refereeing process, and we would like to express our gratitude to the referees. For financial support we are grateful to the Danish Ministry of Trade and Industry and Statistics Denmark. On the production side, we are grateful to Jens Lindhardt for his assistance with the camera-ready copy and to Donald McInnes for his help with proof-reading. Lene Ejerskov and Susanne Hvarre, the conference secretaries, handled the logistics of the conference with professionalism. Finally, the assistance of Boudewijn Smits, Edith Bomers and Erik Oosterwijk of North-Holland has been essential to the book's publication.

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1. Using Dynamic General Equilibrium Models for Policy Analysis: Introduction

by

Glenn W. Harrison, Svend E. Hougaard Jensen, Lars Haagen Pedersen and Thomas F. Rutherford

The metaphor of "overlapping generations" is a useful way to describe the current state of general equilibrium modeling. Over the last three decades these models have grown up to the point where they are being routinely used in day-to-day policy settings. There is overlap in many dimensions: the type of models being constructed, the range of policy issues being evaluated, the software available to undertake simulations, and clearly the natural ageing of the modelers themselves! This conference succeeded in bringing together many of these threads, so that it would be possible to take stock of the current state of policy modeling with general equilibrium models.

In the early days models were almost exclusively static in focus, with some justification given the "degree of difficulty" of simply implementing empirical general equilibrium (GE) models. The range of skills needed were diverse; the modeler needed to marshall input-output tables, balance them with public finance information, infer the correct marginal distortion, code up the correct policy, solve the thing, and decompose results, all with the rigor demanded of elementary micro-economic principles.

One factor which worked to the advantage of the earliest policy models was the desire by economists who pioneered these methods to evaluate concrete policy issues. The best models had a policy focus. Whether it was corporate tax integration in the United States, sectoral tariff reform in Australia, or global trade policy negotiations pursuant to the GATT, the need to speak to a concrete issue provided a structure that helped guide the modeler when deciding where to concentrate scarce energies. Over time, the skills developed in looking at domestic tax issues naturally merged with the skills needed in looking at trade reform, again motivated by a specific policy need: to evaluate the welfare and revenue

consequences of tariff reforms urged by the World Bank, when the lost tariff revenue was to be replaced by some domestic tax increase. This juxtaposition illustrates wonderfully the real strength of GE models in a policy setting. If the government budget is to balance, and there is to be a revenue-neutral reform, some distortions will be lowered and some will be raised. So what is the net effect?

Second-best policy issues such as these gave GE modelers some grounds for validly claiming that their "theory with numbers" was providing more insight than could be gained by "mere theory." Clearly the two are complementary. However, most serious policy issues force the analyst to either ignore the problem (by positing the existence of a lump-sum, distortion-free, tax instrument) or get very explicit (by assuming some structure and working through the numbers systematically). The importance of second-best considerations will be a staple of good GE models, and the chapters in this volume are no exception.

It was also the need to consider specific policy questions that forced GE modelers to venture into the realm of inter-temporal and dynamic models. It was well understood from theory that tax policies affecting investment incentives could have an important impact on economic growth, yet quantification of these effects required an explicit consideration of inter-temporal behavior. Similarly, announcement effects could not be even considered if the decisions they were to affect did not have an inter-temporal component. Policies designed to evaluate inter-generational impacts needed to have multiple generations explicitly modeled, which required life-cycle considerations to be given attention. Policies with long-term impacts, such as global carbon taxes, required some longer-term focus. And the policy encouragement of growth in developing countries needed growth to be treated endogenously. As a result of these types of policy issues, the derived demand for explicit modeling of dynamics grew. The chapters in this volume illustrate well the range of dynamic models being used for different purposes.

While earlier dynamic models required specialized algorithms and model implementation, a common feature of many of the analyses presented in this book are that they are implemented used general-purpose software. Through a combination of improvements in computational power and improvements in the efficiency and robustness of algorithms for solving systems of equations and complementarity problems, dynamic modeling has become a matter of adding a t (time) and g (generation) subscript to demand and supply functions from the

corresponding static models. In the original works (as described by Kotlikoff in chapter 2), dynamic analysis required specialized approaches which often masked the model features which were held in common with the multi-sectoral static framework.

Another sub-plot in the papers in this volume is that a dynamic framework is essential for sorting out the relative merits of capital versus labor taxation. The classical Harberger model, the forerunner of most computable GE models in use today focused on the efficiency costs of income taxes, with a specific focus on the un-taxable leisure margin. Early dynamic models focused on the efficiency cost of taxes applied to capital through their effect on savings and growth. An important innovation in this volume are the studies by Lau (chapter 7) and Ho and Jorgenson (chapter 8) which endogenize human capital accumulation, raising a new and potentially important element into the analysis of the relative merits of capital versus labor taxes.

This volume contains eleven original chapters, with a rich array of policy settings. The issues considered include trends in the policy use of dynamic GE models, environmental policy, trade liberalization and enlargement of the European Union, the impact of education and tax policy on human capital accumulation, tax policy and the labor market, and public finances in relation to population ageing.

Trends in OLG modeling

In chapter 2, "The A-K OLG Model: Its Past, Present and Future," Laurence J. Kotlikoff provides historical perspective on the well-known dynamic simulation model originally presented in Auerbach and Kotlikoff [1987], now widely referred to as the A-K OLG model. The chapter describes, in an informal and entertaining manner, the origin of that model. It also explains how the model has been developed over the years to allow for endogenous labor supply, endogenous retirement, and intra-generational heterogeneity, amongst other factors. The most important lessons to emerge from simulations with the A-K OLG model are that transitions are generally very slow, that short-run effects can have the opposite signs as long-run effects, and that redistribution effects appear to matter much more than incentive effects for the saving and growth responses to fiscal policies. A number of policy experiments are illustrated, including tax reform and privatization of social security. Kotlikoff makes

several suggestions for future extensions of the model, such as migration, changing demographics, arbitrary initial conditions, liquidity constraints, and idiosyncratic uncertainty. An appendix lays out the model's current structure and solution procedure. Overall, the chapter has a strong appeal as an accessible survey of the development of the influential AK-OLG model.

Environmental policy

In chapter 3, "How Valuable Are Delayed Cutbacks in Danish Carbon Emissions?", Jesper Jensen analyses the timing of carbon emissions abatement policies for a given abatement target. It is generally agreed within the scientific community that anthropogenic emissions of carbon dioxide into the atmosphere have contributed to a steady increase in global temperatures. Temperature increases could have adverse consequences for persons alive in the next century. There is a major policy debate about who should abate emissions and how soon abatement should be undertaken. The debate over the inter-temporal efficiency of abatement provides the basis for Jensen's study. The analysis uses a Ramsey-type model with an infinitely-lived, representative household that maximizes a discounted utility function defined over consumption in all periods until the terminal year 2050. On the production side, the model specifies 7 sectors, 5 of which are energy oriented. Labor supply is exogenous, and there is a putty-clay assumption for the current capital stock. All new capital formation remains fully mobile across sectors.

Jensen first studies the costs of achieving the current national goal in Denmark of reducing CO_2 emissions to 80% of their 1998 level by 2005. This scenario entails a welfare loss in present value equal to 20% of GDP in 1997 compared to the benchmark situation maintaining the current level of emissions. This scenario is then compared to a policy that reaches the same cumulative emissions target by 2050, but postpones the first year of constant, reduced emissions from 2005 to 2015. The simulation results show that the delay reduces total costs by 7.5%. A sensitivity analysis reveals that both the quantitative and qualitative results are fairly robust with respect to changes in several key assumptions. Overall, an important policy question in a clean and simple way, with results that should affect the policy debate over the timing of carbon abatement.

While the study by Jensen ignores inter-generational effects of climate change policies, chapter 4 on "Carbon Abatement, Technical Change and Intergenerational Burden Sharing," by Thomas F. Rutherford, uses an overlapping generations model for Denmark. In addition to providing an explicit representation of the inter-generational incidence of policy measures, this model allows for technical change to occur through the introduction of new technologies such as wind power, combined heat and power, new transportation technologies, and a backstop technology that effectively places an upper bound on the cost of abatement. The policy scenario considered by Rutherford is similar to the scenario considered by Jensen in chapter 3. Danish policy objectives include a 20% reduction from 1998 emissions levels by 2005, and a 21% reduction from 1990 emissions levels by 2010. Denmark's abatement policy is represented as a 20% cutback from current emissions over a 10 year period, a scenario which is representative of Denmark's obligations to the European Union, as well as the Kyoto protocol.

Rutherford finds that the possibility of technical change has important implications for the overall cost of carbon abatement, as well as the allocation of those costs between current and future generations. Comparing the results obtained using a Ramsey-type model and an OLG framework, he finds that the two models can produce very different estimates of the efficiency cost of abatement if the revenue from carbon taxes is recycled through capital taxes. These differences are less pronounced if the revenue is recycled through consumption taxes. A slower pace of technical change, along with aggressive emissions targets, places greater burdens on future generations. Revenue recycling through cuts in capital taxes yields smaller, negative impacts on GDP compared to lowering less distortionary taxes on consumption. However, capital tax recycling shifts the burden from older to younger generations and produces a more uneven distribution of abatement costs across generations compared to labor tax recycling.

Overall, the important insight is that carbon abatement policy can significantly affect inter-generational burden sharing, and may produce a pronounced trade-off between equity and efficiency. It is not the case that one can comfortably discuss inter-temporal efficiency and ignore inter-generational burdens: there is a trade-off that depends on the type of model adopted and the substantive policies considered.

Trade policy and enlargement

The inclusion of Central and Eastern European countries (CEEC) in the European Union (EU) is a major political and economic issue in Europe. The enlargement of the EU is a challenge for the current member states, since the CEECs have a substantially lower income per capita than the EU average and have large agricultural sectors. Hence, those countries would become net recipients of EU funds if the EU retains present policies. Apart from the political aspects of enlargement, the question for existing EU member states is whether the economic benefits of the enlargement are sufficient to counterbalance the likely budgetary costs of the enlargement. Chapter 5, "Eastern Enlargement of the EU: A Dynamic General Equilibrium Perspective," by Christian Keuschnigg and Wilhelm Kohler, considers the economic effects for the case of Austria. The model used for this analysis is a Blanchard-type OLG model. The production side of the model consists of 18 sectors, where each sector has a sector-specific capital stock in the short run due to convex costs of installation. There are skilled and unskilled labor inputs.

The first policy scenario considers the effect of opening up more trade between Austria and the CEEC. This is modeled as a reduction in transaction costs. A second policy scenario considers the EU-enlargement with the first group of countries (Czech Republic, Estonia, Hungary, Poland and Slovenia). This is modeled as a further reduction in transaction costs, combined with an increase in the contribution payments to the EU-budget or a reduction in the provision of agricultural funds. In the first scenario the simulations show that there is a long run welfare gain of approximately 0.3% of GDP for the Austrian economy. Further reductions in transaction costs following enlargement, financed through an increased EU-budget, generates a welfare increase of approximately 0.6%. However, if enlargement is combined with a reduction in the provision of agricultural funds Austria receives a welfare gain of approximately 0.8% compared to the benchmark.

The welfare effect on Austria is unevenly distributed across generations, with the largest welfare gain received by future generations. The simulations show that enlargement will reduce the initial wage dispersion in Austria, by generating a larger increase in the wage rate of low skilled workers. This effect is contrary to the standard assessment of the effects of globalization on the Austrian economy, and appears to be due to sectoral shifts in the output structure of the Austrian economy changing the relative derived demands for skilled and unskilled labor. Finally, Keuschnigg and

Kohler consider the more ambitious enlargement that includes Bulgaria, Latvia, Lithuania, Romania, and the Slovak Republic, along with the previously mentioned countries. This further enlargement generates a further increase in the long welfare in the Austrian economy.

The quantitative effect on the Norwegian economy of recent agreements on trade liberalization is the subject of chapter 6, "Welfare Effects of Trade Liberalization in Distorted Economies: A General Equilibrium Assessment for Norway," by Taran Fæhn and Erling Holmøy. Their model is a Ramsey-type model with infinitely living households and a production side with 34 sectors. The policies evaluated include Norway's association with the common market through the EEA Treaty, Norway's participation in the WTO, the EFTA agreement on fisheries, and an anticipated EEA resolution on shipbuilding. The impact of these agreements is modeled as a reduction in Norwegian non-tariff-barriers, and a reduction in Norwegian subsidies to specific industries.

The total effect of these policy changes is an improvement of the Norwegian terms of trade. The positive terms of trade effect results in increases in both the import and the export share of production. By itself, this terms of trade improvement generates a welfare gain for Norway. However, distortions in the domestic tax system mitigate the welfare gains, such that the resulting welfare gain is 0.8%. Some fraction of the increase in real income associated with trade liberalization is therefore lost, since leisure is a normal good and increases in leisure demand that arise from an initial improvement in real income are welfare worsening due to the wage tax. The net welfare effects are relatively robust to adaptations of the model to include imperfect competition, scale effects, and a "love of variety."

Human capital accumulation

How does the long term incidence of capital and labor income taxes change within a computable life cycle model with allowance for the endogenous formation of human capital? This question is addressed in chapter 7, "Assessing Tax Reforms when Human Capital is Endogenous," by Morten I. Lau. He departs from previous analyses with respect to the allocation of time over the life cycle. The point in time at which the individual retires is determined endogenously, which implies that time is divided between work and training during the first part of the individual's

life, and between work and leisure during the second part of the life cycle.

A single tax experiment is implemented. The capital income tax is reduced, and the labor income tax is determined endogenously to re-balance the public budget. The introduction of this tax reform has a positive effect on investment in physical capital, while reducing investment in human capital. Hence employment falls, and people retire earlier. The results also suggest that it may be efficient to have a lower tax rate on capital income compared to the tax rate on labor income, rather than just one comprehensive tax rate on all types of income. Increasing the proportional tax rate on labor income does not affect the private return to human capital investment because the opportunity cost of education is reduced by the same rate. A proportional labor income tax thus implies that the private and social rates of return on human capital investment are identical. However, the proportional tax rate on labor income distorts the intra-temporal allocation between the private consumption of goods and leisure. A capital income tax, on the other hand, reduces the private return to financial saving compared to the social return. The results indicate that the inter-temporal distortion due to the capital income tax is more significant than the intra-temporal distortion due to the labor income tax, and that a shift in the tax burden from capital to labor could lead to a more efficient tax system.

In chapter 8, "Educational policies to stimulate growth," Mun S. Ho and Dale W. Jorgenson explore how education and schooling impact economic growth. They present a GE model that is estimated on the basis of long time series, simulates the expected demographic transition of the U.S. economy, and incorporates skill formation in a dynamic setting. Households optimize over an infinite-horizon, and have perfect foresight. On the production side it is assumed that production functions display constant returns to scale without perpetual growth, except for exogenous technological progress.

The policy objective is to demonstrate how the steady state of the economy, as well as the transition path, would be affected by different levels of education. The GE framework captures the obvious short-run effects: that more spending on education means higher taxes, and that more students to school mean a reduction in the supply of labor. The results also show that efforts to increase human capital through more spending and higher taxes will result in less physical capital and lower welfare. This result contrasts with partial-equilibrium analyses, which have suggested that the welfare gains from additional human capital

accumulation could be quite large. However, it does conform with previous GE studies showing that human capital and physical capital can be close substitutes. Hence policies that are good for the accumulation of human capital may be bad for the accumulation of physical capital, and *vice versa*.

Tax reforms and the labor market

One of the main issues in the tax literature of the last decade has been the welfare effect of environmental tax reforms. This type of reform shifts taxation from a distorting tax on labor, for example, to a tax on polluting emissions such as carbon emissions. This could generate a so-called "strong double dividend," where the level of emissions is reduced and welfare is increased from the tax reform by itself. Since no existing tax systems are likely in a second-best optimum, the scope for a double dividend is always present. In chapter 9, "Labour Market Rigidities and Environmental Tax Reforms: Welfare Effects of Different Regimes," Brita Bye considers the case for Norway. The GE model used for this analysis is the same as the model used in chapter 6. The importance of assumptions concerning the labor market are stressed, by considering three different formulations of the labor market. The first formulation is to assume traditional competitive labor markets, the second formulation entails labor markets with restricted mobility, and the third formulation is a unionized labor market.

The simulation results suggest that there is a strong double dividend in Norway, irrespective of the labor market formulation. However, the welfare effects can differ significantly with the alternative formulations. Using the competitive labor market as methodological benchmark, the welfare effect is larger if the labor market is unionised. This positive welfare effect appears to be due to the reduction in involuntary unemployment that follows from the reduction in the distorting tax on labor. On the other hand, introducing restricted mobility, in the sense that workers who are laid off from polluting industries are unable to find jobs in the rest of the economy, implies that welfare is reduced compared to the competitive case. This effect is due to the increase in involuntary unemployment. However, even in this case a small increase in the carbon tax tends to generate a double dividend in Norway.

The persistence of unemployment in Europe has generated policy