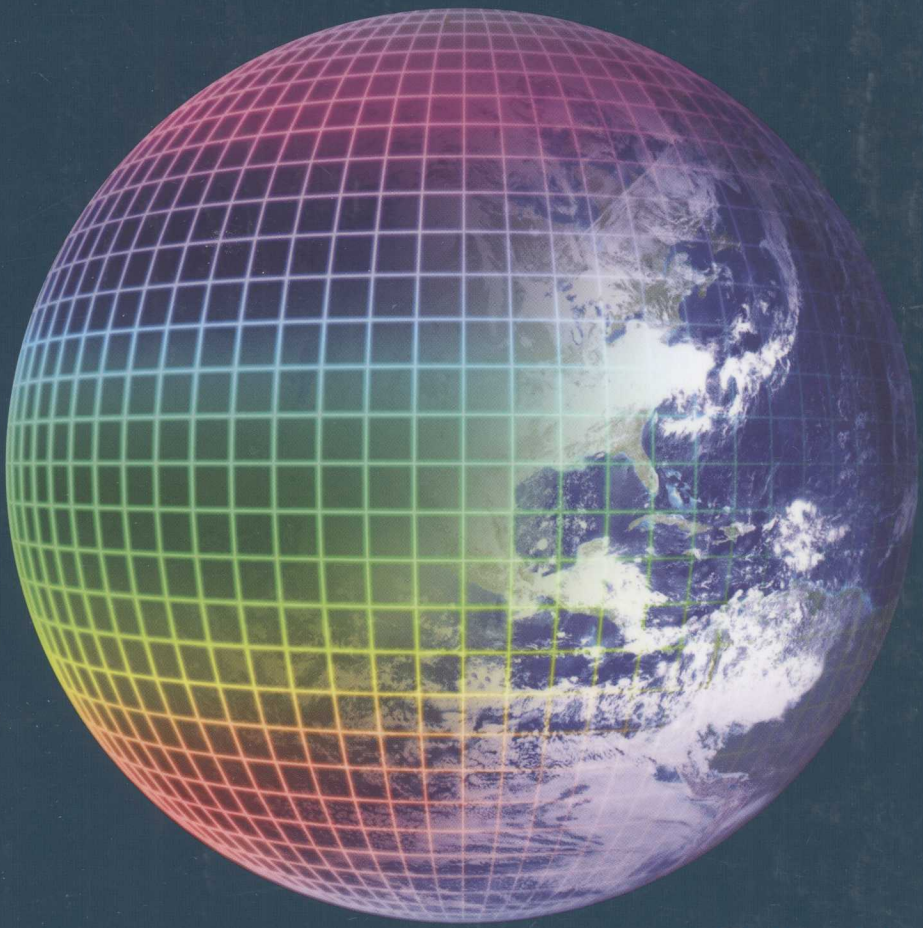
DYNAMIC MODELING AND APPLICATIONS FOR GLOBAL ECONOMIC ANALYSIS



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Dynamic Modeling and Applications for Global Economic Analysis

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DYNAMIC MODELING AND APPLICATIONS FOR GLOBAL ECONOMIC ANALYSIS

A sequel to *Global Trade Analysis: Modeling and Applications* (Cambridge University Press, 1997, edited by Thomas W. Hertel), this book presents the technical aspects of the Global Trade Analysis Program's global dynamic framework (GDyn) and its applications within important global policy issues. The book covers a diverse set of topics including trade reform, growth, investment, technology, demographic change, and the environment. Environmental issues are particularly well suited for analysis with GDyn, and this book covers its uses with climate change, resource use, and technological progress in agriculture. Other applications presented in the book focus on integration issues such as rules governing foreign investment, e-commerce regulations, trade in services, harmonization of technical standards, sanitary and photo-sanitary regulations, streamlining of customs procedures, and demographic change and migration.

Elena I. Ianchovichina is Lead Economist for the Middle East and North Africa region of The World Bank. Since joining The World Bank in 2000, she has served in its Research Department, East Asia and Pacific Region, and managed the Economic Policy and Debt Department's program on inclusive growth. Her work has focused on country-specific analyses of economic growth, emerging Asia, and fiscal and trade reform. Dr. Ianchovichina has published more than twenty articles in a variety of journals, including the *Canadian Journal of Economics, Contemporary Economic Policy, Review of International Economics, World Bank Economic Review,* and *Ecological Economics.* She received Purdue University's 2008 Apex award for outstanding contributions to quantitative trade analysis.

Terrie L. Walmsley is an Associate Professor at Purdue University and a Principal Fellow and Associate Professor at the University of Melbourne, Australia. Dr. Walmsley is also the Director of the Center for Global Trade Analysis, the Purdue home of the Global Trade Analysis Project, a global network of 8,500 researchers from 150 countries (www.gtap.org). Dr. Walmsley leads the construction of the GTAP Data Base, a global database used worldwide to examine the impact of international trade and environmental policies. Her research has focused on international trade in goods and services and the movement of capital and labor across national boundaries; it has been used extensively by The World Bank.

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Over the years a number of researchers contributed to this project in different ways. Ken Itakura worked on updating the tab file to match the GTAP v6.2 tab file, whereas Csilla Lakatos developed postsimulation processing programs. We are grateful to the instructors of and participants in the dynamic GTAP short courses held at Purdue University in 2000, 2006, 2008, and 2010. These courses provided an opportunity for fruitful exchanges on important research questions concerning the theory behind the model and many of the applications discussed in this book. We would like to recognize in particular Robert A. McDougall, Anna Strutt, Thomas W. Hertel, Alla Golub, Csilla Lakatos, Ken Itakura, Amer Ahmed, Angel Aguiar, Peter Minor, Peter Dixon, and Kevin Hanslow. Finally, we are grateful to the three anonymous reviewers for their useful insights and comments.

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PART I

INTRODUCTION AND OVERVIEW

ONE

Introduction

Elena I. Ianchovichina

The objective of the Global Trade Analysis Project (GTAP), launched in 1992, was to lower the cost of entry into the world of applied computable general equilibrium (CGE or AGE) modeling using a global, economy-wide framework. The birth of the GTAP project and the subsequent publication of the GTAP book (Hertel 1997), which documented the model structure, data, and software, were timely because there was an increasing demand for quantitative analyses of trade policy issues on a global basis. Most notably, the Uruguay Round negotiations under the auspices of the General Agreement on Tariffs and Trade (GATT) were a catalyst in moving forward the GTAP database and model, as were the heated debates over the North American Free Trade Agreement (NAFTA) and subsequently the World Trade Organization's (WTO) Doha Development Agenda. In response to this demand, the GTAP project grew from a few people in a handful of countries in 1992 to more than 8,500 people from 140 countries in 2010; the GTAP book has been widely cited; and the GTAP model and data have been actively used by a large number of public institutions around the world and in analyses on various topics published in numerous refereed journals, books, and reports.

The dynamic GTAP model (GDyn) is a follow-up to the GTAP model (Hertel 1997). It is a recursively dynamic applied computable general equilibrium framework of the world economy that extends standard GTAP to include features that improve the treatment of the long-run in the model, but retains all its other features. Part II of this book documents these extensions to the GTAP model structure and data, the construction of a baseline, and the software. Part III consists of six applications of the model that highlight the versatility of the modeling framework.

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1. Motivation for the GDyn

The main objectives of GDyn are to provide a better treatment of the long-run within the GTAP framework and a way of tracing the evolution of the global economy through time. A good treatment of the long-run and issues of timing is essential when analyzing the economics of some of today's most prominent global issues, such as climate change, natural resource management, globalization, and demographic change. For a good long-run treatment, we need international capital mobility that will allow us to capture how policy shocks and other developments diversely affect incentives to invest in different regions. We also need to determine regional capital stocks, which is most satisfactorily done in a dynamic model. GDyn aims to facilitate analysis of the economic implications of climate change, economic growth, and other issues affecting the global economy in a dynamic context.

2. Data for GDyn

With capital mobile between regions, the database for GDyn needs to extend beyond the standard GTAP Data Base. It needs to allow for foreign and domestic ownership of regional capital stocks, as well as international income payments and receipts. This is necessary because the assets owned by a region need no longer be the assets located in that region and the income generated by the assets in a region need no longer accrue to that region's residents. To limit the burden of data construction for GDyn, and because data on foreign assets and liabilities are limited and inconsistent globally, we prefer a treatment of foreign assets that is parsimonious in its data requirements. This treatment is discussed in Chapters 2 and 4.

New pieces of data are also needed to accommodate the new lagged adjustment, adaptive expectation theory of investment. In GDyn investors act so as to eliminate disparities in expected rates of return, not instantaneously, but progressively over time. The parameters determining the speed of convergence in rates of return are presented in Chapter 3. These parameters have either been estimated econometrically or have been informed by econometric or empirical evidence.

Finally, macroeconomic and policy projections data are needed for the construction of a baseline scenario. On the macroeconomic side these data include projections of gross domestic product, gross domestic investment, population, and skilled and unskilled labor. On the policy side, these data include policies that are important elements of the baseline scenario, and their inclusion will depend primarily on the issue being examined. For

example, if one is interested in free trade agreements among the Association of South-East Asian Nations (ASEAN) countries, it would be important to incorporate those agreements that have already been ratified. However, if one is interested in agreements between the EU and South Africa, then agreements between ASEAN countries may be of limited concern. Chapter 5 discusses the construction of the macroeconomic and policy projections.

The data for GDyn adhere to the same principles as the GTAP Data Base – public availability at cost, upgrades coordinated with the release of the standard GTAP Data Base, and broad participation. The network of GDyn users includes those who would identify areas for improvement or extension of the database and who are encouraged to work with GTAP staff to incorporate their ideas into future database releases. The operational concept that has worked for years for the GTAP Data Base continues to apply in the case of GDyn: "If you do not like it, help fix it!"

3. Model and Software

The investment theory and the treatment of financial assets and associated income flows in GDyn are discussed in Chapter 2. The main features include the treatment of time; the distinctions between physical and financial assets, and between domestic and foreign financial assets; and the treatment of capital and asset accumulation, assets and liabilities of firms and households, income from financial assets, and the investment theory of adaptive expectations. The discussion focuses on those areas in which the new treatment of the long-run required us to make changes to the standard GTAP model. All distinguishing features of GTAP, apart from those discussed in Chapter 2, remain unchanged. These include the treatment of private household behavior, international trade, and transport activity. Auxiliary variables in GTAP that facilitate the construction of alternative closures, including partial equilibrium specification, are preserved in GDyn.

The GDyn model is implemented using the GEMPACK software suite (Harrison and Pearson 1998) developed at the Centre of Policy Studies and IMPACT Project, Monash University, under the direction of Kenneth Pearson. Other general equilibrium models solved using the GEMPACK software suite include the standard GTAP model and the Monash model of Australia. The software that makes it easy to run GDyn is RunDynam, which is a program created by Ken Pearson and specially tailored to the needs of GDyn. It allows users to examine the data, construct and modify experiments, produce solutions, and examine results. Users who wish to alter the underlying theory of the model will need to acquire GEMPACK

and RunDynam from the Centre of Policy Studies at Monash University, Australia. Those who wish to make their own data aggregations will need to purchase the GTAP Data Base and GDyn extensions from the GTAP Center, Purdue University, United States.

At the time of publication of this book, a number of applications of GDyn have been published in refereed journals, professional books, and magazines, and a half dozen are currently underway worldwide. These applications address a variety of issues, including trade policy reform, regional integration, equilibrium real exchange rate analysis, technical change, natural resource management, global climate change, and demographic change. Six of these applications were selected for inclusion in this book. They are representative of the work being undertaken currently with GDyn.

4. Short Course in Dynamic Global Economic Analysis

Although its dynamic nature makes GDyn somewhat more complex than standard GTAP, the use of GDyn has spread around the world. Since 2000, when the Center for Global Trade Analysis held the first short course in Dynamic Global Economic Analysis, the model has been used by economists in universities and public research institutions in more than 20 countries on five continents. The dynamic GTAP course was offered again in 2006, 2008, and 2010, and there are plans to have this course offered at regular intervals in different parts of the world.

5. Overview of the Book

This book is divided into four parts, of which this chapter is the first. Part II presents the technical aspects of the GDyn framework. In six chapters it covers data and new theoretical extensions that enable improved treatment of the long-run in GDyn, the construction of a baseline, welfare analysis in a dynamic model, and the software used to run the model. Chapter 2 presents an in-depth exposition of the investment theory and the treatment of financial assets and associated income flows. Chapter 3 discusses the techniques used to determine the magnitude of behavioral and entropy parameters used in the theory presented in Chapter 2. Chapter 4 discusses the data construction and aggregation programs. Chapter 5 documents the steps involved in building a baseline for GDyn. Chapter 6 develops a method for decomposing welfare in GDyn. Chapter 7 presents the software for running the model and analyzing model solutions.

Part III of the book is a collection of six applications of GDyn. These are grouped by topic and examine a diverse set of issues: trade reform, growth and investment, climate change, natural resources, technology, and demographic change. The first of these applications, Chapter 8, is authored by Walmsley, Hertel, and Ianchovichina. This application formally explores the linkage between China's WTO accession and investment in China in the period between 1995 and 2020. The application is similar to the one presented in Walmsley and Hertel (2001), who also used GDyn, but makes a number of enhancements, including the depiction of the duty drawback regime in China and the liberalization of trade and investment in services. Walmsley, Hertel, and Ianchovichina find that investment in China has increased substantially as a result of China's accession. Accession doubles the extent of foreign ownership of Chinese assets relative to the no-accession baseline by 2020. Central to this increase in foreign ownership is the expected catch-up in the productivity of the services sectors driven by the opening of these sectors to foreign investment. The resulting impact on GDP is also large – 22.5% higher than the baseline by 2020. China's welfare gain (15% by 2020) is dampened because a substantial share of additional investment comes from overseas. These estimates are far larger than those predicted by earlier studies, which ignored the reforms affecting the services sectors of China and which also abstracted from capital accumulation and international capital mobility.

In Chapter 9 Hertel, Itakura, and Walmsley turn their attention to issues that are the focus of "new-age" free trade agreements (FTAs), such as rules governing foreign investment, e-commerce regulations, trade in services, harmonization of technical standards, sanitary and phyto-sanitary regulations, and the streamlining of customs procedures. They use GDyn, which is well suited to capturing the long-run effects of new-age FTAs, to assess the dynamic gains from the FTA between Japan and Singapore. They find that the impacts of this new-age FTA on bilateral trade and investment flows are significant – with customs automatization playing the most important role in driving increases in merchandise trade. The FTA also boosts rates of return in the two economies, thereby increasing both foreign and domestic investment as well as GDP.

Chapters 10 and 11 address issues related to climate change and the natural resource implications of technical change in agriculture. In Chapter 10, Ianchovichina, Darwin, and Shoemaker incorporate different types of land in GDyn to analyze the impact of a slowdown in agricultural total factor productivity (TFP) growth on agriculture and forest resources. They find that a slowdown in agricultural TFP growth might lead to higher crop

prices in all regions, with South East Asia facing the steepest increases. A slowdown in agricultural TFP growth might also be accompanied by increases in conversion rates of forestland to farmland as well as by a worsening of environmental or ecological damages on the remaining forestland. In Chapter 11, Golub and Hertel investigate the role of globalization and growth in determining long-run patterns of land-use change. They are able to isolate the impact on land markets of the following elements of globalization: population growth, real income growth, access to forestland, and international trade. Of the two demand-side factors, real income growth is more important than population growth. The potential for accessing new forestland plays a small role in dampening the growth in global land rent, whereas international trade plays a very substantial role in mediating between the land-abundant, slower growing economies of the Americas and Australia/New Zealand, and the land-scarce, rapidly growing economies of Asia. When combined, the forces of globalization are expected to play a large role in determining the pattern of land-use change.

Chapter 12, authored by Itakura, Hertel, and Reimer, incorporates into GDyn existing econometric evidence of the strong correlations that exist between firm productivity, on the one hand, and investment and trade on the other, to study the economic effects of a recently proposed East Asian FTA. They find that although conventional applied computable general equilibrium (AGE) modeling effects predominate and are reinforced by the productivity effects, in some cases, the latter actually reverse the changes predicted by the conventional effects.

In the final application, Chapter 13, Tyers and Shi introduce a global demographic submodel into a version of GDyn in which regional households differ by gender and age group. Their goal is to study the global implications of demographic change. They find that increased longevity of the global population slows down growth in real per capita incomes, lowers saving rates, and alters the distributions of global economic activity in favor of those regions with high aged labor force participation.

Part IV of the book offers an evaluation of the GDyn framework. In Chapter 14, Golub and McDougall evaluate the evolution of foreign assets and liabilities in GDyn by comparing the model-determined and actual trends in foreign assets, foreign liabilities, and net foreign assets – all as a share of wealth. Their choice of the first two indicators is driven by their interest in regional wealth allocation and the composition of capital in GDyn. The third indicator is of more general interest and is often used in discussions in the financial press and among policy makers in reference

to the sustainability of net foreign liabilities. How large can gross and net foreign assets and liabilities get in GDyn simulations? Have such changes been observed in past data? These are the types of questions Golub and McDougall ask in Chapter 14. For this comparison they use a country portfolio database constructed by Kraay et al. (2000). The database covers 68 countries, including all industrial countries and many developing countries, for the years ranging from 1966 to 1997. Golub and McDougall find that, unlike in real data, net foreign positions in GDyn grow without bounds in the very long-run. As economies with high saving rates in the initial year (e.g., China) grow, there is a glut of savings in GDyn, and rates of return to capital fall without bound in the very long-run. The reason for this is the assumption of fixed propensity to save in each region in GDyn. To ensure that, as in reality, gross foreign assets and liabilities do not diverge without bound in the very long-run, Golub and McDougall endogenize the saving rate in GDyn and make it a function of the share of wealth in income. The new theoretical structure supports balanced growth scenarios, stabilizes global rates of return to capital, and prevents net external assets or liabilities from growing implausibly large. Chapter 15 by Ianchovichina and Walmsley provides an overall evaluation of the effort to date, as well as some observations about the future course of global economic analysis with GDyn.

6. Reader's Guide

For those who wish to master the material presented in the book, the most efficient approach is to read the book chronologically – beginning with the model structure, reading about the parameters and data, accessing the software from the Web site, mastering the construction of the baseline, and only then turning their attention to the applications and the evaluation of the model.

However, many readers may be interested in a particular topic. Those interested in climate change, natural resources, and demographics might want to start with Chapters 10, 11, and 13, respectively. Having read these chapters and understanding the essence of the changes introduced to address these topics, you might want to study the features of the main dynamic model. For this you need to backtrack to Chapter 2 and then go to Chapters 3–7. Those interested in trade policy and investment might want to look at Chapters 8, 9, and 12 first, before going back to the details of the dynamic model presented in Chapters 2–7.

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