The Global Environment, Natural Resources, and Economic Growth

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"We have not inherited the earth from our ancestors, we have only borrowed it from our children."

—Ancient Proverb

"Act so that the effects of your action are compatible with the permanence of genuine human life."

—Hans Jonas (1903–1993),
German-born philosopher,
taught at the New School, 1955–1976

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Preface

Recently public attention has turned toward the intricate interrelation between economic growth and global warming. This book focuses on this nexus but broadens the framework to study this issue. Growth is seen as global growth, which affects the global environment and climate change. Global growth, in particular high economic growth rates, implies a fast depletion of renewable and nonrenewable resources. Thus the book deals with the impact of economic growth on the environment and the effect of the exhaustive use of natural resources as well as the reverse linkage. We thus address three interconnected issues: economic growth, environment and climate change, and renewable and nonrenewable resources. These three topics and the interrelationship among them need to be treated in a unified framework. In addition, not only intertemporal resource allocation but also the eminent issues relating to intertemporal inequities, as well as policy measures to overcome them, are discussed in the book. Yet more than other literature on global warming and resources, we study those issues in the context of modern growth theory. Besides addressing important issues in those areas we also put forward a dynamic framework that allows focus on the application of solution methods for models with intertemporal behavior of economic agents.

The material in this book has been presented by the authors at several universities and conferences. Chapters have been presented as lectures at Bielefeld University; Max Planck Institute for Demographic Research, Rostock; Sant'Anna School of Advanced Studies of Pisa, Itlay; University of Technology, Vienna; University of Aix-en-Provence; Bernard Schwartz Center for Economic Policy Analysis of the New School, New York; and Chuo University, Tokyo, Japan. Some chapters have also been presented at the annual conference of the Society of Computational Economics and the Society of Nonlinear Dynamics and Econometrics. We are grateful for comments by the participants of those workshops and conferences.

Some parts of the book are based on joint work with co-authors. Chapter 14 is based on the joint work of Almuth Scholl and Willi Semmler, and chapter 15 originated in the joint work of Malte Sieveking and Willi Semmler. We particularly want to thank Almuth Scholl and Malte Sieveking for allowing us to use this material here.

We are also grateful for discussions with and comments from Philippe Aghion, Toichiro Asada, Buz Brock, Graciela Chichilnisky, Lars Grüne, Richard Day, Ekkehard Ernst, Geoffrey Heal, James Ramsey, Hirofumi Uzawa, and colleagues of our universities. We thank Uwe Köller for research assistance and Gaby Windhorst for editing and typing the manuscript. Financial support from the Ministry of Education, Science and Technology of the State of Northrhine-Westfalia, Germany, and from the Bernard Schwartz Center for Economic Policy Analysis of the New School is gratefully acknowledged. Finally we want to thank numerous anonymous readers and Terry Vaughn and Catherine Rae at Oxford University Press, who have helped the book to become a better product.

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Introduction

The globalization of economic activities since the 1980s and 1990s, accelerated through free trade agreements, liberalized capital markets, and labor mobility, has brought into focus the issues related to global growth, resources, and environment. The industrialization in many countries in the past 100 years and the resource-based industrial activities have used up resources, mostly produced by poor and developing countries. The tremendous industrial growth in the world economy, particularly since World War II, and the current strong economic growth in some regions of the world, for example in Asia and some Latin American countries, have generated a high demand for specific inputs. Renewable as well as nonrenewable resources have been in high demand, and they are threatened with being depleted. In particular, the growing international demand for metals and energy derived from fossil fuels, as well as other natural resources, which are often extracted from developing countries, has significantly reduced the years to exhaustion for those resources.

It is true that technical progress has reduced the dependence of modern economies on natural resources, which is beneficial for their conservation, but this positive effect mostly holds for advanced economies producing with up-to-date technologies. Developing nations producing with older technologies usually do not have this advantage. In addition, several of those countries have experienced high growth rates over the past years. In particular, China and India have grown very fast over the past decades. These two countries alone comprise a population of more than two billion citizens, and the high growth rates in these countries have led to a dramatic increase in the demand for natural resources.

Whereas modern economies, like those in Western Europe and Japan, could reduce their dependence on nonrenewable resources, this does not necessarily hold for renewable resources. In particular, many oceans have been overfished for a long time. Current estimates assume that about 75 percent of the worldwide fish population is overfished. Although this problem has been realized by scientists and politicians, the short-run gains seem to be more important than conservation, leading to a severe threat to some fish species.

There is also an issue of inequity involved. An overwhelming fraction of resources, located in the South, are used up in the North, in the industrialized countries, and the North has become the strongest polluter of the global environment. Many recent studies have confirmed that the emission of greenhouse gases is the main cause for global warming. Moreover, concerning intergenerational equity, current generations extensively use up resources and pollute the environment. Both produce negative externalities for future generations.

Indeed, not only does the environmental pollution strongly affect the current generation, but the environmental degradation affects future generations as well. It is true that as for the dependence on natural resources, technical progress has led to a more efficient use of technologies so that emissions of some pollutants have been reduced considerably. Indeed, in a great many regions in Europe and in the United States, for example, air pollution has been successfully reduced, leading to a cleaner environment. However, this does not hold for all types of emissions. In particular, emissions of greenhouse gases are at a high level and still increasing. Concerning greenhouse gas emissions, the high standard of living of modern Western societies makes these countries emit most of these gases, if measured per capita. Since the conference and protocol of Kyoto in 1997, the global change of the climate has become an important issue for academics as well as politicians. Although some countries had cast doubt on the fact that it is humankind that produces a global climate change, this question seems to have been answered now. There is vast evidence that the climate of the Earth is changing due to increases in greenhouse gases caused by human activities (see, for example, the report by Stern 2006, 2007, and the IPCC report 2007).

Although some may argue that to address and study those issues on global growth, environment, and resources, large-scale macro models may be needed. Yet when those models are solved through simulations, the mechanisms get blurred, and policy implication are not transparently derived. This book takes a different route. In the context of modern small-scale growth models, where the behavior of the agents and the framework are well defined, clear and coherent results are derived that may become useful guidelines for policy makers and practitioners.

The outline of the book reflects the discussed major issues. Part I deals with the environment and growth. We present models that incorporate the role of environmental pollution into modern growth models and derive optimal abatement activities as public policy. Part II models global climate change in the context of economic growth models. Policy implications are direct and transparent. Part III evaluates the use and overuse of nonrenewable and renewable resources in the context of intertemporal economic models. Aspects of global and intertemporal inequities as well as policy measures to overcome them are discussed in each part of the book.

PART I

The Environment and Economic Growth

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Introduction and Overview

There are numerous economic models that study the interrelation between economic growth and the environment. We focus on a class of models in which economic activities lead to environmental degradation, and thus economic activity negatively affect the utility of households or the production activities of firms. This line of research goes back to Forster (1973) and was extended by Gruver (1976). Forster (1973), for example, studies a dynamic model of capital accumulation, the Ramsey growth model, with pollution as a byproduct of capital accumulation that can be reduced by abatement spending. In the long run, this model is characterized by a stationary state where all variables are constant unless exogenous shocks occur.

Another early contribution in environmental economics is the book by Mäler (1974), which can be considered as a classical contribution in this field. Mäler analyzes several aspects associated with environmental degradation in different frameworks, such as a general equilibrium model of environmental quality and an economic growth model incorporating the environment. But Mäler assumes a finite time horizon and is less interested in the long-run evolution of economies, in contrast to Forster (1973).

If one studies a growth model and intends to analyze the long-run evolution of economies, models with constant variables in the long run are rather unrealistic. With the publication of the papers by Romer (1986, 1990) the "new" or endogenous growth theory has become prominent. The major feature of models within this line of research is that the growth rate becomes an endogenous variable, the per capita income rises over time, and the government may affect growth through fiscal policy, for example. Concerning the forces that can generate ongoing growth, one can think of positive externalities associated with investment, the formation of human capital, or the creation of a stock of knowledge through R&D spending (for a survey, see Greiner et al. 2005).

Another type of model in endogenous growth theory assumes that the government can invest in productive public capital, which stimulates aggregate productivity. This approach goes back to Arrow and Kurz (1970), who presented exogenous growth models with that assumption in their book. The first model in which productive public spending leads to sustained per capita growth in the long run was presented by Barro (1990). In his model, productive public spending positively affects the marginal product of private capital and makes the long-run growth rate an endogenous variable. However, the assumption that public spending as a flow variable affects aggregate production activities is less plausible from an empirical point of view, as pointed out in a study by Aschauer (1989).

Futagami et al. (1993) have extended the Barro model by assuming that public capital as a stock variable shows positive productivity effects and then investigated whether the results derived by Barro are still valid given their modification of the model. However, the assumption made by these researchers implies that the model has transition dynamics, which does not hold for the model when public spending as a flow variable shows productive effects. In the latter case, the economy immediately jumps on the balanced growth path. The model presented by Futagami and colleagues is characterized by a unique balanced growth path, which is a saddle point. Although the questions of whether the long-run balanced growth path is unique and whether it is stable are important issues, they are not frequently studied in this type of research. Most of the contributions study growth and welfare effects of fiscal policy for a model on the balanced growth path.

As to the question of whether public spending can affect aggregate production possibilities at all, the empirical studies do not obtain unambiguous results. However, this is not too surprising because these studies often consider different countries over different time periods and the effect of public investment in infrastructure, for example, is likely to differ over countries and over time. A survey of the empirical studies dealing with that subject can be found in Pfähler et al. (1996), Sturm et al. (1998), Romp and de Haan (2005), and Semmler et al. (2007).

Problems of environmental degradation have also been studied in endogenous growth models. There exist many models dealing with environmental quality or pollution and endogenous growth (for a survey, see, for example, Smulders 1995 or Hettich 2000). Most of these models assume that pollution or the use of resources influences production activities either through affecting the accumulation of human capital or by directly entering the production function. Examples of that type of research are the publications by Bovenberg and Smulders (1995), Gradus and Smulders (1993), Bovenberg and de Mooij (1997), and Hettich (1998). The goal of these studies, then, is to analyze how different tax policies affect growth, pollution, and welfare in an economy. But as with the approaches already mentioned, most of these models do not have transition dynamics or the analysis is limited to the balanced growth path. An explicit analysis of the dynamics is often beyond the scope of these contributions. An exception is provided by the paper by Koskela et al. (2000), who study an overlapping generations model with a renewable resource that serves as a store of value and as an input factor in the production of the consumption good. They find that indeterminacy and cycles may result in their model, depending on the value of the intertemporal elasticity of consumption.

In part I we analyze a growth model where pollution only affects utility of a representative household but does not affect production activities directly through entering the aggregate production function. However, there is an indirect effect of pollution on output because we suppose that resources are used for abatement activities. Concerning pollution, we assume that it is an inevitable byproduct of production and can be reduced to a certain degree by investing in abatement activities. As to the growth rate, we suppose that it is determined endogenously and that public investment in a productive public capital stock brings about sustained long-run per capita growth. Thus we adopt that type of endogenous growth models that was initiated by Barro (1990), Futagami et al. (1993), and others as mentioned.

Our approach is closely related to the contributions by Smulders and Gradus (1996) and Bovenberg and de Mooij (1997), who are interested in growth and welfare effects of fiscal policy affecting the environment but do not explicitly study the dynamics of their models. Concerning the structure, our model is similar to the one presented by Bovenberg and de Mooij (1997) with the exception that we assume that public capital as a stock enters the aggregate production function, whereas Bovenberg and de Mooij assume that public investment as a flow has positive effects on aggregate production.

In chapter 2 we present a simple variant of an economic model with environmental pollution and productive public capital. This model will be analyzed assuming a logarithmic utility function. Chapter 3 studies both growth and welfare effects of fiscal policy. In particular, we analyze how the long-run balanced growth rate reacts to fiscal policy and to the introduction of a less polluting technology. Further, we study the effects of fiscal policy, taking into account transition dynamics, and we analyze welfare effects of fiscal policy on the environment on the balanced growth path as well as the social optimum. In chapter 4 we generalize our model and allow for a more general isoelastic utility function. The goal, then, is to give an explicit characterization of the dynamic behavior resulting from more general assumptions. An extension of the model is presented in chapter 5 , where we assume that environmental pollution as a stock negatively affects utility of the household. In this variation of the model, we consider three different scenarios: first, we analyze a scenario with a constant stock of pollution; second, we study a scenario with an improving environmental quality; and finally, we analyze a scenario in which environmental pollution grows at the same positive rate as all other endogenous variables.