VALUING THE FUTURE

Economic Theory And Sustainability

ECONOMICS FOR A SUSTAINABLE EARTH SERIES

Geoffrey Heal

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Economics for a Sustainable Earth Series,
Graciela Chichilnisky and Geoffrey Heal, Editors

Economic forces are driving dramatic changes in the environment of our planet. Our grandchildren may live in a world radically different from our own. Between our lifetimes and theirs, economic activity may cause changes in climate and in plant, animal, and insect populations greater than any since the evolution of human societies, with far-reaching consequences for human well-being. This poses a challenge to economic analysis, for economists have traditionally taken the economy's material and biological surroundings as given, independent of economic activity. Books in this series grapple with the consequences of human domination of global ecological and biogeochemical systems.

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Preface

Sustainability is a metaphor for some of the most perplexing and consequential issues facing humanity. These might even include the very survival of our species. Certainly they include the survival, and extension to the rest of the world, of the lifestyle now practiced in the industrial countries. Almost without exception, these issues are rooted in our economic behavior and organization. Yet it is not until very recently that there has been an economic theory of sustainability, or even any systematic application of existing theories to the issues to which it alludes. I see this as a major omission and am puzzled by the slowness of our profession in addressing a set of questions that offer intellectual challenge and policy relevance in abundance. Perhaps they have just not yet been placed clearly on the intellectual map. Whatever the reason, I hope that this book will help to place them more firmly on our research agenda. I hope it will also suggest that economics can contribute to understanding sustainability and that thinking about sustainability can help us to understand economics. Scientific disciplines grow by interacting with problems that stretch them to their limits, and there are many such problems in the complex of environmental problems associated with sustainability.

One of the most intriguing of this set of problems is how we value the future, hence the title of this book. Economists have not really come to grips with valuing events that are centuries away. Typical economic time horizons differ by an order of magnitude from those that are typical for ecological or climatological phenomena. For economists, thirty years is a long time; for scientists concerned with the evolution of the environment, it is short. A lot of what follows is about reconciling these perspectives.

I develop here a framework for thinking about some aspects of sustainability. The framework is one for modeling the dynamic interactions

of economic and biological systems, studying the time paths that can emerge from these interactions, and then selecting one or more of these as optimal. I investigate alternative approaches to optimality, inquiring whether there is a concept of optimality that captures the concerns that underlie the emerging interest in sustainability. I suggest that the essence of sustainability lies in three points: a treatment of the present and the future that places a positive value on the very long run, recognition of all the ways in which environmental assets or natural capital contribute to economic well-being, and recognition of the constraints on economic activity implied by the dynamics of environmental assets.

My analysis shows that embodying these concerns in a concept of optimality has important implications for patterns of optimal resource management over time, for the valuation of environmental assets, and for the way in which the use and the services of environmental assets are recorded in national income accounting and indeed for the way concepts such as national income are formalized. Observing these principles leads to more conservative patterns of resource use, higher shadow prices on resources, and a redefinition of several resource-related items in national income accounts.

Much of the work reported here was completed in collaboration with Andrea Beltratti and Graciela Chichilnisky. Geir Asheim and Keisuke Ohsumi have also been unusually generous with their time and helpful with their comments. In addition, I have benefited from conversations with and comments from Yuliy Barishnikov, Michael Hoel, Bill Nordhaus, Charles Perrings, Harl Ryder, Bob Solow, and Jon Strand.

An early version of this manuscript was presented as the Leif Johansen Lectures given at the University of Oslo, March 1995. A later version provided the basis for a series of lectures at the Université Paris X-Nanterre in May of 1997. I am grateful for the invitations to give these lectures, as they provided me with the incentives to complete this project. They also gave me the opportunity to benefit from discussions with the students who attended my lectures. The book was finished during a Fulbright Professorship at the University of Siena.

This is a moderately technical book. Ideally, the reader comes equipped with two types of knowledge. One is knowledge of basic resource allocation theory applied to natural resources, as presented in my earlier book with Partha Dasgupta [41]. Another is a reasonable grasp of the mathematics of dynamic optimization. Despite these ideal prerequisites, the book is close to being self-sufficient in that much of the necessary background is summarized, albeit briefly. The first chapter provides an overview of the issues, methodology, and conclusions, and could serve as a summary for

the nontechnical reader. I see the audience as advanced undergraduates, graduate students, researchers and technically oriented policy makers in economics, and graduate students and professionals in other scientific disciplines with an interest in thinking economically about sustainability and environmental conservation in the long run.

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Chapter 1
What Is Sustainability?

If a man takes no thought about what is distant,
he will find sorrow near at hand. (Confucius)[1]

Can existing patterns of human activity safely and sensibly continue unaltered over the long term, or will such continuation lead to unacceptable consequences? This is the central issue underlying current discussions of sustainability.[2]

Some of the concerns prompting this question are by now a familiar part of the daily news agenda. Human consumption of carbon-based fuels, together with our depletion of carbon-consuming forests, is altering the natural carbon cycle of the planet, which since time immemorial has balanced carbon production by animals (humans included) against the consumption of carbon by plants and microorganisms and sequestration in the oceans. The disturbance of this cycle is increasing the proportion of carbon dioxide in the earth's atmosphere, and there is now a consensus that this is slowly increasing the mean temperature of the planet. We do not understand fully the consequences of such a change: there seems to be a chance that for some regions of the world they could be apocalyptic and irreversible. Such observations lead one naturally to question whether current patterns of energy use can continue without eventually provoking unacceptable outcomes: in short, whether they are sustainable.

Similar questions are prompted by the observed loss of biodiversity. According to distinguished biologists, we are driving species extinct at a

[1]Quoted in Newman [84].

[2]This definition, although far from those common in economics, is very close to that used by Holdren, Daily, and Ehrlich [64], who say "A sustainable process or condition is one that can be maintained indefinitely without progressive diminution of valued qualities inside or outside the system in which the process operates or the condition prevails."

rate unparalleled since the demise of the dinosaurs, more than fifty million years ago. These are irreversible, final losses; whatever our technological sophistication, we cannot re-create that which is extinct. The extinction is largely a result of habitat change, and also in some degree a consequence of pollution. Biodiversity is important in many different ways, so again the question arises: are the dimensions of human activity leading to biodiversity loss sustainable? Or will they impoverish us?

A key point is that it is economic forces, economic decisions, that are driving phenomena such as global warming and biodiversity loss. The decision to use fossil rather than solar energy is an economic decision; the decision to use more rather than less energy is also an economic decision. The changes in habitat which lead to extinction are again economically driven; it appears to be more profitable to chop down rainforests and plant coffee or other cash crops than to leave them intact. The choice of polluting rather than nonpolluting technologies is another economic choice. So behind many of the offending dimensions of human activity are economic choices and calculations. We will not significantly change the potentially unsustainable aspects of human activity unless we can develop an economic environment within which they are no longer attractive. In other words, we need to change the rules of the economic game so that it becomes economically rational to pursue sustainable alternatives. A good economic system harnesses private interests in the public good, so that as Adam Smith noted:[3]

> Every individual ... neither intends to promote the public interest, nor knows how much he is promoting it. He intends only his own security, his own gain. And he is in this led by an invisible hand to promote an end which was no part of his intention. By pursuing his own interest he frequently promotes that of society more effectively than when he really intends to promote it.

How could this work? Economic decisions are guided by prices: prices fix the costs of alternative ways of doing business, and the returns from business opportunities. So the phrase the "rules of the economic game" refers to the ways in which prices are determined. We need prices that reflect better the costs associated with nonsustainable policies. This is not a new observation: a long tradition of environmental economics emphasizes the differences between the private and social costs of environmentally harmful activities, and the need to devise economic institutions to close

[3][102], book 4, chapter 2, first page.

that gap. In a general sense this book is a contribution to that tradition. We have already made progress in that direction, through institutions such as tradable emission quotas and pollution taxes.

There are, however, several dimensions in which the issue of sustainability is different from, and more demanding than, the earlier issues raised by environmental economics. One is the time dimension. Sustainability is above all about what happens in the long term: about whether we can continue "forever" as we are, and whether the economic rules of the game lead us to make choices that are viable in the long term. Here *the long term* denotes a period much longer than that normally considered in economic analyses, typically at least half a century and sometimes as long as several centuries. These time periods pose a particular challenge for the economists' traditional practice of discounting, and an aim of this book is to consider the alternatives.

A second dimension in which the current concern with sustainability is particularly challenging is that it requires us to address the interactions between our economic systems and a wide range of natural ecosystems. We are coming to realize, in part through the process of losing them, that environmental assets are key determinants of the quality of life in most societies. These assets—forests, clean water, clean air, species, rivers, seas, and many more—are not like physical or financial assets: they are alive and have dynamics, requirements, imperatives of their own. Recognizing this and recognizing that they provide the essential infrastructure for human existence is a key step on the road to building an economic framework that can contribute to the development of sustainable policies. In modeling this framework, one has to draw on the recent literature on ecosystem services and their role in sustaining human societies: the volume edited by Daily [37] is a key contribution here.[4]

My aim here is to review the existing conceptual economic literature on sustainability, and then to develop the concept further within the context of models of the optimal dynamic management of an economy endowed with natural resources. I will use this to suggest that we can give a clear analytical content to the idea of sustainability and can build on this to establish frameworks for project evaluation, shadow pricing, and environmental accounting, all of which are consistent with the underlying theoretical framework, in precisely the same way that current approaches to project evaluation and national income accounting are consistent with and draw their intellectual justification from the

[4]See also the book by Baskin [10].

discounted utilitarian approach to optimal growth theory.[5] In the next section I review the existing literature on sustainability, and I also review certain existing concepts that, although not explicitly linked to sustainability, can contribute to the formalization of this concept. Prominent among these are the Fisher-Lindahl-Hicks concept of income as the maximum that we can consume without reducing our wealth and the Meade–Phelps–Robinson concept of the golden rule of economic growth as the configuration of the economy leading to the highest permanently maintainable consumption level.

It is not my intent here to cover all possible interpretations of sustainability or all aspects of a theory of sustainability. My goal is to develop a framework for analyzing sustainability in the context of economic dynamics and of the design and management of economic development strategies. I use a deterministic framework, one that is highly aggregated and simplified, an extension of Solow's classic growth model [103] as modified by Dasgupta and Heal [40]. Though simple, this model has been found by many researchers to yield interesting and robust insights, and the same proves to be true in the present context.

My agenda does not address many aspects of sustainability, some of them unquestionably very important. But one has to start somewhere. Aspects that are central but omitted are those stemming from uncertainty,[6] technical change, and the need to manage the use of global commons or public goods such as the atmosphere and the oceans. Over long time horizons, which are central to discussions of sustainability, uncertainty is pervasive: what will the world look like one century ahead? Two centuries? Technical change is one of the main sources of this uncertainty: in principle, technical change could render many currently threatening practices benign or unnecessary. Economists have often modeled technical change by an assumption of exponentially rising productivity. However, the current problem seems altogether too important to use such a naive approach: any constraint can be avoided in the long run on such a scenario. And although there are models of endogenously generated technical change, we actually know very little about the factors generating enhanced productivity. A satisfactory treatment of these topics will have

[5] I am referring to the fact that most of the current practice of cost-benefit analysis has its origins in the works of Dasgupta, Marglin, and Sen [45] and of Little and Mirrlees [77], who took the relatively abstract ideas of the theory of optimal economic growth and applied these to an analysis of the rules governing the use of shadow prices for project evaluation.

[6] See the paper by Asheim and Brekke [9] and the volume by Chichilnisky, Heal, and Vercelli [32], and in particular Beltratti, Chichilnisky, and Heal [14]. See also Chichilnisky and Heal [28] for a nontechnical overview.

to wait, but in the meantime there are aspects of sustainability on which we can make progress.

In the management of the global commons, a key issue is the assignment of property rights in and management of the use of global public goods such as the atmosphere, the oceans, and reserves of biodiversity. Many complex and interesting economic issues arise when one considers how best to manage these. Of course, they are public goods, so we have to be concerned about the possibility of "free riding": they are a very particular type of public goods, namely privately produced public goods. They are privately produced in that the amounts of carbon dioxide or chlorofluorocarbons in the atmosphere are the results of large numbers of decisions made by individuals and firms about lifestyles, technologies, and so on. This introduces an element into the attainment of efficient allocations that is absent from conventional public goods such as defense or law and order, and has interesting implications for the use of tradable permits, a method of establishing property rights and harnessing market forces in the service of the environment that is rapidly gaining attention. In particular, it implies that the initial distribution of property rights among participants in the permit market determines whether the equilibrium attained by the market after trading will be Pareto efficient. These issues are studied in detail in Chichilnisky and Heal [29] and Chichilnisky, Heal, and Starrett [31].

1.1 History of Sustainability

Only recently has *sustainability* become an influential and widely used word. At the 1992 Earth Summit in Rio, considerable attention was devoted to sustainability, and the concept is embodied in the resulting UN Framework Convention on Sustainable Development. In addition, the Organization for Economic Cooperation and Development, the United Nations Committee on Trade and Development, the U.S. Presidential Council on Sustainable Development, and many other domestic and international policy-oriented institutions are devoting time and energy to the analysis of sustainable policies. An environmentalist might find this encouraging. An economic theorist or a public policy economist, on the other hand, could easily find this very worrying, for sustainability is not part of our lexicon; it has no established economic meaning. There is a literature on sustainable development, but this is recent and partial at best, and one certainly could not say that it represents an economic consensus on how to formalize and make operational the ideas

associated with sustainability. The concepts and concerns that underlie sustainability are not new. Certainly they go back at least to the 1970s; the Bariloche model (Hererra et al. [62], Chichilnisky [18]) emphasized relevant issues in 1976:

> Underdeveloped countries cannot advance by retracing the steps of... the developed countries.... It would imply repeating those errors that have lead to... deterioration of the environment.... The solution... must be based on the creation of a society intrinsically compatible with its environment. ([62], p. 24)

The concept of "a society intrinsically compatible with its environment" is central: the goal of the literature on sustainability is to understand what this might be and how to implement it. This same model also introduced the concept of "basic needs" as a way of formalizing the minimum requirements needed for successful participation in society and linked the satisfaction of these basic needs with "the creation of a society intrinsically compatible with its environment." Around the same time, the United Nations Conference on the Human Environment in Stockholm (1972) coined the phrase *sustainable development*, and the United Nations Environment Program was founded.

More recently, the Brundtland report [110] produced the following widely-quoted remark: "Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs." The timeliness of this report, and the ease with which this phrase rolls off one's tongue, has something to do with the attention given to the concept in recent years. However, this ease is a little misleading: there is no corresponding ease of intellectual assimilation.

Two key concerns are expressed in Bariloche and Brundtland: recognition of the long-run impact of resource and environmental constraints on patterns of development and consumption, and a concern for the well-being of future generations, particularly as this is affected by their access to natural resources and environmental goods. These are an alternative way of articulating the concern that started this chapter, namely whether existing patterns of human activity can safely and sensibly continue unaltered over the long term and whether such continuation will lead to unacceptable consequences.

The framework I develop in the following chapters addresses both of these concerns, which seem very well founded and deserving of explicit recognition and analysis.