Chapter 1
Introduction

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Markets are among the oldest and most powerful of social institutions. They are a dominant force in the world economy today and in many ways a force for change and progress. Market economies have led the race for industrialization, overcoming planned economies and traditional agricultural societies during the course of the twentieth century. The most attractive feature of markets is the efficiency with which they allocate resources, requiring minimal intervention once an appropriate legal infrastructure is in place. This was Adam Smith's vision of the "invisible hand" and was formalized in the neoclassical theory of competitive markets that has prevailed in the Anglo-Saxon world since the 1950s.

Since World War II international markets have been remarkably successful. In this period they achieved, to a great extent, a life of their own. World trade increased at least three times more than world production. Even the United States, traditionally an isolated economy, has more than doubled the proportion of trade to economic activity so that international trade today accounts for 30% of gross national product (GNP). The process of industrialization became an irresistible trend in the twentieth century, made global by the dynamics of international markets.

While propelling industrial society forward, markets have also led to excessive use of natural resources. Industrialization to date has been based on energy. It has been, and continues to be, based on the burning of fossil fuels and the attendant emission of carbon dioxide. Scientists now believe that carbon emissions can cause climate change. Economic activity is the fundamental driving

force of climate change, and the success of international markets has magnified the use of fossil fuels and other natural resources worldwide.

The international market mediates the relationship between industrial and developing countries, the North and the South. Indeed the developing South specializes in resources that account even today for 70% of Latin American exports and almost entirely for those of Africa, whereas the industrial North specializes in products intensive in capital and knowledge. With few exceptions economic development can be read from the composition of a country's exports. The most successful industrializing nations, the Asian Tigers, have swiftly moved into technology-intensive products and have shaped their markets to fit their development needs.

Since the end of colonialism, international markets have perpetuated a pattern of economic development in which the world's less advanced countries play, to a great extent, the role of resource producers and exporters. This pattern of trade is to some degree explained by the historical difference in property rights between the industrial nations of the North and the developing nations of the South.[1] Countries in the latter hold most resources as common property; in industrial economies these are, on the whole, private property. Differences in property rights have been invoked successfully as a possible explanation of the fact that the South overextracts natural resources for the international market, selling these below real costs (Chichilnisky, 1994). As a result, the North overconsumes resources, and the South overextracts them. In a world where agricultural societies trade with industrial societies, international markets magnify the extraction of resources, and as a result exports of natural resources and their consumption in industrial countries exceed what is optimal.

Almost paradoxically it seems possible that the market institution could solve some of the problems that it helped create. This possibility and the requirements for achieving it are the main themes of this book. The chapters here study the role of environmental markets in moderating today's use of environmental resources. How can markets achieve this goal? The idea is to create and allocate new property rights on the use of environmental resources—local and global—and to allow these to be traded in organized markets. This is an idea in the tradition of Coase, and one of the earliest developments is in Dales (1968). In this book we refer to such markets as *environmental markets.* Environmental markets can operate in many ways. One can trade rights to the use of water bodies or to the use of the atmosphere of the planet for disposing of greenhouse gases. In environmental markets the traders can be individuals or

[1] See Chichilnisky (1994).

corporations. They can also be countries. Such markets already exist in the United States, as permits to emit sulfur dioxide are traded at the Chicago Board of Trade. Following the Clean Air Act of 1990, electric utilities were assigned rights to emit sulfur dioxide up to a specified overall level and were also given the ability to write contracts to trade these rights in open markets.

Because emission markets assign a price to the right to emit, they add a cost to the use of the atmosphere. The cost involved arises either from the need to purchase permits when one exceeds one's allotment or from the opportunity cost of using one's permits allotment rather than selling them at the market price. In all cases environmental markets make environmental resources more expensive and thus discourage their use. Thus, they can induce more rational use of resources globally. This is how markets can help control the overuse of natural resources. Although the idea of using markets to increase the cost of resources is simple, environmental markets themselves are somewhat complex and as yet little understood. The purpose of this book is to advance our understanding of environmental markets so that they can achieve their full potential as a tool of environmental policy.

Two main characteristics separate environmental markets from traditional markets. The first is that environmental markets trade *public goods,* by which we mean goods that are not rival in consumption. An example is the fraction of carbon dioxide in the planet's atmosphere, an amount that is the same for all. The second distinguishing characteristic is that the public goods that are traded are not standard but are privately produced public goods. This means that they are produced by individuals in the course of their everyday lives: By driving cars and choosing to heat our homes, we "produce" atmospheric quality. Thus, environmental markets trade *privately produced public goods.* As the chapters in this book demonstrate, markets with privately produced private goods behave quite differently from standard markets and require a somewhat distinct institutional framework, which is discussed in the following pages.

As a brief background it is useful to point out that the study of markets with public goods goes back to the work of Lindahl, Bowen, and Samuelson (see Atkinson and Stiglitz, 1980), formalized later by Foley (1970) in a general equilibrium context. It is well known that markets with public goods are less efficient than standard markets. Typically, they induce inefficient outcomes. In the case of markets for emission permits, each trader has an impact on everyone's welfare through their emissions, yet their private actions do not take into account the benefits that their emission abatement could produce for others. This miscalculation leads the economy to underinvest in the public good. This might well represent today's problems of global atmospheric quality. Each country benefits the entire world when abating their carbon emissions, yet the

benefits they receive are only a fraction of the total, thus leading to less abatement than would be optimal for the world.[2] Markets with public goods lead generally to a less-than-efficient allocation of resources.

To solve this dilemma Lindahl suggested using a different type of market, one with "personalized" prices. In his scheme different traders pay different prices for the public good, depending on their marginal valuations. He showed that when using such prices, markets reach efficient solutions. However, Lindahl's solution is generally considered impractical because one trader can "buy" from another the right to pay less, thus inducing arbitrage among the traders. In the end this can lead to a totally different solution from that intended, one that is no longer efficient. To avoid such outcomes this book remains within the traditional formulation of a competitive market: one good, one price, as opposed to Lindahl-style individualized prices. The chapters in this book study environmental markets that are competitive in the sense that they assign each good one price that is the same for all traders, and no trader has an influence on prices. Although this is a realistic formulation, the problem that Lindahl identified still remains: Efficiency is generally lost when trading public goods in competitive markets. This book proposes a new solution to this dilemma, based on property rights, as discussed below.

A traditional solution that is generally advocated to achieve efficiency in the provision of public goods is for the government itself, rather than market forces, to determine the quantity of the public good produced. However, this solution will not work because the public goods considered here are privately produced. They are produced by individuals in the course of their private lives (e.g., in burning fossil fuels for transportation or for home heating), not by governments. It is not reasonable to expect governments to tell people how much to drive their cars or how and how much to heat and cool their homes, so government determination of the allocation of public goods is impractical in this case, as are personalized prices. Thus, two conventional ways of achieving efficiency in markets with public goods—namely, personalized prices and government choice of the amount of the public good—are not realistic in our case. A new approach is required, and this is a main topic of the chapters in this book.

The chapters in this book look at an alternative way of recovering efficiency in markets with public goods, one that has not been considered until now: the allocation of initial property rights on the privately produced public goods, that is, the rights assigned to the traders before they engage in trading. As a typical example we consider the rights to emit gases into the atmosphere. Re-

[2]For more details, see Heal (1994).

cently, such rights have been the subject of policy in the United States (the Clean Air Act allocates rights to emit sulfur dioxide across utilities), and globally (the Kyoto Protocol specifically allocates obligations to reduce carbon dioxide emissions across the industrial nations over a certain period). Rights and obligations are two sides of the same coin and can be used interchangeably in this context. It is widely believed that property rights is an area fraught with social conflict, and to a great extent this is correct. However, in the global environment area these rights are yet to be allocated, so the matter is somewhat open, in contrast with the allocations of, for example, land rights, which are to a great extent already allocated worldwide. Thus, it can be said that it is realistic to consider policies about how rights to use the environment should be allocated. In addition, this is also timely and to a great extent necessary, as the process of allocating rights to environmental use is advancing globally with as yet little understanding of its consequences.

The property rights policies proposed here are especially appealing because they can lead to win-win solutions for all the traders concerned. Indeed chapter 3 in this volume shows that an appropriate allocation of property rights on the use of the atmosphere can lead to efficient allocations in markets in which there is a single price for public goods. This is a somewhat surprising result, as it is well known that single-price markets might not yield efficient solutions in markets with public goods. Furthermore, under certain conditions identified in the articles by Chichilnisky (1993) and Chichilnisky and Heal (1994), the latter reprinted here as chapters 7, reallocating property rights to favor the lower-income countries can make them, as well as the industrialized countries, better off. This leads to so-called win-win strategies and is a result with obvious policy attractions. The discovery of these properties of emissions markets has many intellectual and policy implications, some of which are discussed here and have formed the focus of this book: the issues of equity and efficiency in environmental markets.

As already mentioned the markets considered here are standard competitive markets and as such have a single price for each traded good, or the same price for all traders. The chapters in this book show that competitive markets with privately produced public goods are more complex than standard markets for private goods. Nevertheless, the authors of this book believe that it is worth understanding their properties, because environmental markets are starting to play an important role. They include water markets and markets for trading emission permits. Both air and water quality are privately produced public goods. The destruction of biodiversity by habitat fragmentation and by pollution is also a public good (bad), again privately produced, and the results presented here can apply equally to biodiversity use. As the value of environmen-

tal assets becomes more widely understood, markets with privately produced public goods will achieve an increasingly important role.

Other types of markets that also trade privately produced public goods are becoming increasingly important, including markets for the use of intellectual property, such as software products and biotechnology. Knowledge-based goods are similar to environmental assets in that they are privately produced but are nevertheless public goods in the sense that they are not rival in consumption. Thus, markets for privately produced public goods include knowledge markets as well as environmental markets. Both types of markets are likely to play an important role in the decades to come, so it is important to understand their properties and the institutions that are needed to support efficient outcomes. Property rights are important institutions and, as shown here, can be crucial for efficiency.

Markets with privately produced public goods were studied some time ago by Laffont (1977) and others in a partial equilibrium world. This book looks at the problem in a general equilibrium framework, namely, when all markets, for private and public goods, occur simultaneously and interact.

The problems that occupy us here are new, as are the solutions. This book originated from results obtained by Chichilnisky (1993), followed by Chichilnisky and Heal (chapter 7) and Chichilnisky, Heal, and Starrett (chapter 3). These results originated in the context of an OECD policy proposal about global carbon taxes:[3] Chichilnisky (1993) and later Chichilnisky and Heal (1994) addressed the following questions. Given that global emissions of carbon dioxide should be reduced by a certain amount, how should this reduction best be distributed between countries? Should each reduce its emissions by an equal amount? Should the rich countries bear most of the burden? The poor countries? Until these articles were written, it had been a widespread presumption that a given amount of emission abatement would generally have a lower cost in developing than in industrial countries, implying that for efficiency the burden of abatement should be borne disproportionately by developing countries. Underlying this argument was a presumption that the efficient attainment of a given total level of abatement would require the equalization of marginal abatement costs across countries. This would mean that we would start abating where these marginal costs are lower, which was widely assumed to be in developing countries. Thus, in this line of argument developing countries should have been the first to abate and the ones to bear the attendant costs. Chichil-

[3]Chichilnisky acted as an adviser to the Economics Division of the OECD in this context, and Chichilnisky (1993) represents part of the output.

nisky (1993) and later Chichilnisky and Heal (1994) noted that this reasoning is incorrect: Unless unrestricted lump-sum transfers between countries are carried out, Pareto efficiency does not require that marginal abatement costs be equalized. Generally, abatement should take place in the countries that have higher income. Although somewhat surprising at first, the point made by these articles is simple. A dollar to an Indian does not have the same welfare implications as a dollar to an American. So the real opportunity costs of abatement to an Indian might be higher than that to an American even though the dollar cost is lower. Chichilnisky (1993) and Chichilnisky and Heal (1994) went on to show that, even in a world where developing countries can abate at a lower cost, it might still be preferable for industrial countries to abate first.

These results were somewhat counterintuitive to many and led to an interesting debate. Chapter 9 of this book, by Martins and Sturm, addresses this issue. Martins and Sturm seek to clarify the conditions under which one recovers the conventional wisdom that equating marginal costs leads to efficient outcomes and thus that developing nations who have lower abatement costs should abate first. For this they take a different model than the other authors, one in which the consumer's utilities do not depend on the quality of the environment. Within their specific model they show that equating marginal costs leads to efficient outcomes. In particular, if developing nations would have lower marginal costs for abating emissions, abatement should take place first in developing countries. They also show that if in the same model one introduces dependence of utility levels on the public good, Chichilnisky and Heal's results again hold. Thus, the critical issue here is whether the environmental public good affects utility levels directly or only indirectly through its impact on production. In models in which the environmental good has no impact on welfare, the conventional wisdom prevails; in models in which the environment has an impact on welfare, they do not. In general it seems clear that most of the major environmental public goods affect individual utilities; this happens directly, through their health or the amenities available to them, or indirectly, through the climate. Thus, it seems that the conventional wisdom fails precisely in the most realistic models, those in which the environment has an impact on welfare. Indeed, if the environment had no impact on welfare, one might ask somewhat rhetorically, Why bother with environmental policies and with environmental markets?

The background in which these results emerged is as follows. The first results on privately produced public goods in an environmental context addressed the problem of determining which countries should abate carbon dioxide emissions and by how much without, however, containing explicit markets. It was conjectured by some that the lack of markets for environmental goods could be

the source of the somewhat unexpected results. Thus, the next natural step was to add competitive markets on emission permits to these models. The same results obtained. The model of an environmental market was formalized first in the Chichilnisky, Heal, and Starrett (CHS) chapter in this book; the rest of the chapters follow this basic model. A main result in the CHS chapter, and indeed the main topic of this book, is a deep connection that emerges between efficiency and the distribution of property rights in markets with privately produced public goods. This is a major departure from standard markets, in which equilibria are always efficient. Here the distribution of property rights matters. It is decisive in ensuring that the market achieves efficient allocations.

Chapter 2, by Chichilnisky and Heal, is a survey of the area of tradable emission markets from the perspective of theory as well as policy. It contrasts the use of carbon taxes with an approach based on trading emission permits and explains the efficiency aspects of markets for emissions quotas. It traces the idea of markets for emission rights to the Coasian view of externalities as arising from an absence of property rights. The first explicit formulation of the idea of a market for emission rights seems to be that of Dales (1968).

Chapter 3, by Chichilnisky, Heal, and Starrett, concentrates on the first welfare theorem in markets in which agents trade, at a uniform price, permits to produce privately produced public goods. The total quantity of permits is taken to be fixed by the government at a level consistent with Pareto efficiency (i.e., at a level equal to that at one of the economy's Pareto-efficient patterns of resource allocation). The article shows that even with the total output of the privately produced public good fixed at a level corresponding to a Pareto-efficient allocation, the equilibria are generally inefficient. This is due to the public good nature of one of the goods traded: the quality of the atmosphere of the planet. What is perhaps more surprising is that, without introducing personalized prices, there exist certain allocations of rights to emit from which the market overcomes the ''free rider'' problem and achieves efficiency. Thus, equity and efficiency are not divorced as they are in classical welfare economics. This is an important characteristic of competitive markets for privately produced public goods and one that will have significant implications for environmental markets and markets for knowledge.

Chapter 4, by Heal, checks the robustness of the CHS result. It studies second-best optimality in markets with emission permits. Like the Chichilnisky and Heal (CH) chapter, it asks about the optimal pattern of emission abatement across countries, and like the CHS chapter it asks about the performance of emission markets, but now both issues are studied in the context of a total emission level that does not correspond to a Pareto-efficient allocation. In other words it addresses the same issues as CH and CHS, but in a second-best con-

text. It shows that the results for the second-best case are essentially equivalent to the CHS results in the first-best case. To be precise only certain allocations of property rights in emission permits lead to second-best efficiency (i.e., to efficiency subject to the constraint imposed on total emissions). Competitive trading of arbitrary initial allocations of permits does not generally lead to second-best efficiency. Thus, this chapter extends the earlier results of Chichilnisky and CH to economies in which the notion of efficiency is restricted to a second-best environment in which a political process has imposed an emission total not consistent with Pareto efficiency.

In Chapter 5, Heal and Lin delve further into the robustness of the CHS results. They study a different market equilibrium, one in which the traders take into consideration each other's actions and reach a Nash solution, by which each optimizes their choice of abatement given the abatement by all the other traders. Under these circumstances they show that there are generally unique efficient solutions: A unique quantity is abated, and a unique distribution of abatement exists that leads to an efficient solution. In other words the distributional prerequisites for efficiency are even more demanding in the face of Nash behavior.

In chapter 6, Prat discusses an innovative process of allocation of property rights. He postulates a two-stage process in which the traders are given a given share of the total permits first, and then the total amount is chosen. He proves that, with this process, Pareto efficiency can be restored for market equilibrium under certain conditions.

Chapter 7 is a reprint of Chichilnisky and Heal (1994) and is an extension and generalization of Chichilnisky (1993). This article showed that marginal costs will be equal across countries at a Pareto-efficient allocation if and only if the marginal valuations of the private goods are equal in the two countries, a demanding condition that can be expected only with free transfers across the regions. Originally presented in June 1993 at the OECD Conference on the Economics of Climate Change in Paris, Chichilnisky (1993) also establishes that, with Cobb-Douglas utilities, efficiency requires that the fraction of income that each country allocates to carbon emission abatement be proportional to that country's income level. The richer countries should spend proportionally more than poorer nations in abatement. Furthermore, the constant of proportionality should increase with the efficiency of the country's abatement technology. This implies that industrial nations should allocate a larger proportion of their income to abatement. These observations originated a lively interest in the topic of equity and efficiency in environmental markets, parts of which this book documents.

In chapter 8, Hourcade and Gilotte, both of whom were present at the 1993

OECD conference, revisit the original results establishing that efficiency is not connected with the equalization of marginal costs of abatements as in the standard market with private goods.

Martins and Sturm were also present at the 1993 OECD conference, and in chapter 9 they seek to clarify the conditions under which one recovers the conventional wisdom that equating marginal costs leads to efficient outcomes. For this they take a different model than the other authors, one in which the consumer's utilities do not depend on the quality of the environment. Within this model they show that equating marginal costs leads to efficient outcomes. In particular, if developing nations have lower marginal costs for abating emissions, abatement should take place in developing countries. However, they also show that if in the same model one introduces dependence of utility levels on the public good, the CH results again hold: Efficiency might not be associated with equating marginal emission costs. Thus, the critical issue here is whether the environmental public good affects utility levels directly or only indirectly through its impact on production. In general it seems clear that most of the major environmental public goods affect individual utilities directly, through their health or the amenities available to them or through the climate.

Chapter 10 takes the ideas that are central to the earlier chapters, especially that by CHS, and applies them in a different context, namely, the privatization and securitization of the services provided by natural ecosystems. In this case the focus is on a watershed, a case motivated by the decision of New York City to invest several billion dollars in restoring the ecological integrity of its main watershed in the Catskill Mountains. The nontechnical part of this chapter was published as a commentary in the science journal *Nature* (Chichilnisky and Heal 1998). This is augmented here by a formal model of the privatization and securitization process. The relationship with earlier chapters is that many of the services provided by natural ecosystems are privately produced public goods.

Chapter 11 examines further the issue of equity and efficiency in environmental markets. Indicating that in environmental markets a more sophisticated institutional approach is required for efficient market solutions, Chichilnisky proposes the creation of a new global financial institution for this purpose—an International Bank for Environmental Settlements (IBES)—that would combine market features and the voting participation by industrial and developing nations. The proposal was advanced officially at the 1995 Annual Meetings of the World Bank. The IBES mandate would be to obtain market value from environmental assets without destroying them, and it could assist in the organization, intermediation, and regulation of markets for emissions trading, including the borrowing and lending of emissions rights.

In chapter 12, Werksman presents a lucid discussion of the global negotiations that led to the "Kyoto Surprise," the Clean Development Mechanism (CDM) of Article 12. This is the only one of the flexibility mechanisms of the Kyoto Protocol that includes provisions for both industrial and developing nations. Werksman explores the conceptual roots of different aspects of the CDM, including the pilot phase of "activities implemented jointly," and explores the ambiguities in Article 12 and how the CDM could evolve in the future.

In chapter 13, Chichilnisky draws a similarity between markets for knowledge and environmental markets, both of which can be characterized as markets for privately produced public goods. The chapter derives the appropriate models of competitive markets for knowledge and environmental assets and within these markets characterizes the conditions for Pareto efficiency of allocations with privately produced public goods that are expressed in a manner that is independent of the units of measurement and, in certain cases, similar to the Lindahl-Bowen-Samuelson efficiency conditions in the provision of classic public goods.

The agreements summarized in the Kyoto Protocol to the UN Framework Convention on Climate Change (FCCC) are important to the issues addressed in this book. They represent the first agreement to apply market mechanisms to the control of privately produced public goods at the international level in the context of controlling the emissions of greenhouse gases. The driving force behind the success of that agreement was Ambassador Raúl Estrada-Oyuela, who was then chairman of the UN Negotiating Committee of the FCCC. His diplomatic skills were generally agreed to have been critically important in reaching the Kyoto agreement, and in chapter 14 we have a commentary by Estrada-Oyuela on the process leading to the Kyoto Protocol. The text of the protocol follows in the Appendix.

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