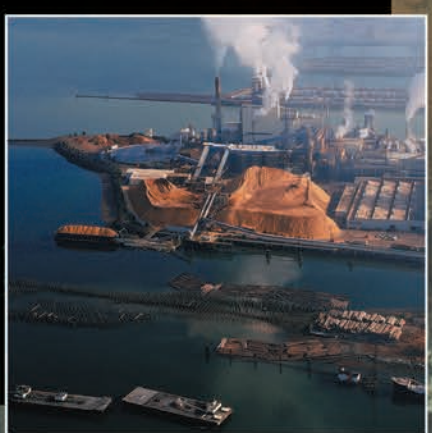
# Policy Instruments for Environmental and Natural Resource Management



Thomas Sterner

# *Policy Instruments for Environmental and Natural Resource Management*

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THE WORLD BANK


# *About Resources for the Future and RFF Press*

RESOURCES FOR THE FUTURE (RFF) improves environmental and natural resource policymaking worldwide through independent social science research of the highest caliber.

Founded in 1952, RFF pioneered the application of economics as a tool to develop more effective policy about the use and conservation of natural resources. Its scholars continue to employ social science methods to analyze critical issues concerning pollution control, energy policy, land and water use, hazardous waste, climate change, biodiversity, and the environmental challenges of developing countries.

RFF PRESS supports the mission of RFF by publishing book-length works that present a broad range of approaches to the study of natural resources and the environment. Its authors and editors include RFF staff, researchers from the larger academic and policy communities, and journalists. Audiences for RFF publications include all of the participants in the policymaking process—scholars, the media, advocacy groups, nongovernmental organizations, professionals in business and government, and the general public.

# *Resources for the Future*

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*Selection of Policy Instruments*



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# *Foreword*

MANY COUNTRIES—both industrialized and developing—face serious problems of natural resource protection and environmental management. The design and implementation of policies that respond to important challenges to economic, ecological, and social sustainability has been debated for many years by two related groups: by governments and other organizations and by academic economists and other policy analysts.

The design and implementation of environmental and natural resource policies has been the focus of growing intensity throughout the world. What began at the 1972 United Nations Environment Summit in Stockholm and was encouraged at the 1992 Earth Summit in Rio de Janeiro assumed center stage at the Rio+10 Summit in Johannesburg in 2002. Governments (particularly in the developing world), national and multilateral development institutions, the private sector, and nongovernmental organizations have been taking action, and the resulting policies often have a regulatory or command-and-control flavor. The effects have been mixed: some successes and a number of disappointments.

On a parallel track, since the 1960s, the design and implementation of environmental and natural resource policies has been the focus of increasingly fruitful research. Much of this work has focused on what can be described as incentive-based policies, which attempt in varying ways to rely more on economic motivations and to provide more flexibility than do traditional regulatory approaches.

Progress in understanding both types of policies has been made, and promising applications can be found today in many developed countries, as well as in the developing world. However, experience in developing countries is more limited, and significant skepticism remains about the applicability of incentive-based policies for the developing world.

In this book, Thomas Sterner successfully advances both conceptual and practical understanding of what needs to be done if good environmental and natural resource policies are to be devised and implemented in different countries, both developed and developing. Based on solid economic theory and consideration of

other social and political aspects, the book begins with a thorough presentation and analysis of the menu of available policies. It then proceeds to a broad discussion of actual and potential applications (pollution, natural resources, and transportation) in different types of economies.

Sterner's survey of the policy landscape develops several important lessons for analysts, policy practitioners, and students. These include the following:

- Properly designed incentive-based policies can and do work, both in protecting the environment and natural resources and in lowering the cost of achieving that goal. Blanket resistance to the use of such policies in some parts of the world, whether due to philosophical stance or lack of information, needs to be reconsidered.
- Badly designed incentive-based policies can be just as ineffective as the alternatives their advocates seek to replace.
- No policy regime, incentive-based or otherwise, can accomplish much without the necessary underlying economic, legal, and technical institutional capacities and an appropriate social milieu. Often these capacities are quite limited in the developing world.
- To succeed, therefore, incentive-based and other policies must be tailored to the existing social context and institutions, and their application needs to be accompanied by capacity building. Analysis and experience teach much, but simple cookbook answers are unlikely to be very successful.

We hope that this fine book will serve as a valuable resource for those practitioners considering and evaluating concrete policy options and for those analysts who seek to provide the intellectual base for such efforts. Given the importance of both protecting natural resources and the environment and doing so cost-effectively, we see no higher priority on the environmental and natural resource policy agenda today and in the future.

John A. Dixon
*The World Bank*

Michael A. Toman
*Resources for the Future*

# *Preface*

THIS BOOK IS INTENDED to be used by individuals who are interested in the selection and design of policy instruments for the environment: university professors, undergraduate or graduate students, analysts who advise policymakers, and, particularly, people in countries that have not yet made extensive use of market-based policy instruments. Its purpose is to pull together the distinct experiences of policymaking that have evolved in the United States, Europe, and other countries of the Organisation for Economic Co-operation and Development (OECD) and also in non-OECD countries, including some formerly planned economies. A wide range of environmental and natural resources issues illustrate points that are ecologically important or good examples of the principles of policy design.

To be sure, this book is not an encyclopedia of resource and environmental problems, a pure textbook in environmental economics, or a mere description of policies. Many important issues are not covered at all, or at least not in proportion to their importance. Theoretical issues are presented as refreshers for readers who have studied some economics rather than as rigorous training for future environmental economists. If it were possible to write a "cookbook" with "recipes" for environmental policymaking, then it really ought to be done. However, the ecological, technical, social, and economic realities of environmental policymaking are so complex that there are no simple guidelines. Instead, in-depth understanding of both the economics and the environmental science is necessary to successfully design good policies.

Only a small amount of mathematics is presented in this book. Although mathematical proofs can greatly aid some readers, they can just as well frustrate others. The text was written to be intelligible even to readers who skim the formulas, so detailed mathematical explanations are presented as supplemental information.

The topics of this book include the key theoretical issues, worldwide applications, and various "brown" and "green" issues. My own personal experience and prior work have necessarily affected my choice of emphases. Although I have a

keen interest in other social and natural sciences, I am first an economist. And even though I tried to cover as many countries as possible to illustrate various economic systems and income levels, because of my experience, cases from Sweden and the United States are overrepresented among the industrialized countries.

Scientific analysis of policy instruments is not new. However, such analysis tends to concentrate on one issue or aspect at a time and tends to be written for specialists. Literature that systematically covers the whole menu of resource and environmental policy issues in different countries is more sparse, and this book is intended to fit in that niche.

# *Acknowledgements*

During the past decade, I have been engaged as a teacher in Sweden and in capacity-building efforts worldwide. The material presented in this book has been extensively tested on students, in courses on natural resources and environmental policy instruments at the University of Gothenburg (Gothenburg, Sweden), at teaching workshops at the World Bank (Washington, DC), and at the African Economic Research Consortium elective course on environmental economics (Nairobi, Kenya). The manuscript or parts thereof were presented at several seminars in economics at the University of Gothenburg, the department of political science at the University of Gothenburg, Resources for the Future (RFF), the Harvard Institute for International Development, and the World Bank. I thank all the participants at these events, who are too numerous to mention. Part of the manuscript also was presented at the Institute of Economic Growth (Delhi, India); thanks to Kanchan Chopra, B.N. Goldar, Shubash Gulati, Srikant Gupta, and M.N. Murthy for valuable comments.

The Environmental Economics Unit at the University of Gothenburg has an extensive collaboration with the Swedish International Development Cooperation Agency (Sida) that includes the Beijer Institute at the Royal Academy in Stockholm, Sweden, as well as several networks for capacity building on various continents. This collaboration has enabled me to work with colleagues and students from countries in Africa, Asia, and Latin America. I acknowledge these coauthors as well as friends and colleagues who have read the chapters or the whole manuscript carefully and provided valuable comments: Hala Abou-Ali, Shakeb Afsah, Wisdom Akpalu, Tekye Alemu, Francisco Alpizar, Greg Amacher, Jessica Andersson, Christian Azar, Razack Bakari, Allen Blackman, Gardner Brown, Dallas Burtraw, Fredrik Carlsson, Nasima Chowdhury, Frank Convery, Håkan Eggert, Anders Ekbom, Jorge Garcia, Gautam Gupta, Henrik Hammar, Winston Harrington, Lena Höglund, Bill Hyde, Olof Johansson-Stenman, Per Kågeson, Beatrice Kalinda, Vinnish Kathuria, Michael Kohlhaas, Gunnar Köhlin, Sandra Lerda, Martin Linde Rahr, Åsa Löfgren, Susanna Lundström, Minhaj

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I started to write this book during a sabbatical spent in Washington, DC (1998–1999). I spent it partly at RFF, which was kind enough to offer me a Gilbert White Fellowship, and partly at the Environment Department of the World Bank. In different ways, both experiences were stimulating. Several colleagues at RFF (in addition to those already mentioned) helped me to understand U.S. policymaking: Ruth Bell, Jim Boyd, Joel Darmstadter, Carolyn Fischer, Suzi Kerr, Ray Kopp, Alan Krupnick, Molly Macauley, Virginia McConnell, Dick Morgenstern, Richard Newell, Wally Oates, Karen Palmer, Ian Parry, Paul Portney, Roger Sedjo, and David Simpson.

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*To Greta for a good past*

*To Gustav, Erik, and Kalle for a sustainable future*

*To all of you and to Lena for sharing the present*

# *Abbreviations*

| | |
|---|---|
| CAAA | Clean Air Act Amendments |
| CARB | California Air Resources Board |
| CDM | Clean Development Mechanism (of the Kyoto Protocol) |
| CEO | chief executive officer |
| CERCLA | Comprehensive Environmental Response, Compensation, and Liability Act |
| CFC | chlorofluorocarbon |
| CO | carbon monoxide |
| $CO_2$ | carbon dioxide |
| COP | Conference of the Parties (to the UNFCCC) |
| CPR | common property resource |
| DDT | (an effective but dangerous pesticide) |
| DNA | deoxyribonucleic acid (essential molecule for genetic information) |
| EEC | European Economic Commission |
| EPA | U.S. Environmental Protection Agency |
| EPCRA | Environmental Protection and Community Right to Know Act (United States) |
| ESMAP | World Bank's Energy Sector Management Assistance Program |
| ETBE | ethyl *tert*-butyl ether |
| E.U. | European Union |
| GATT | General Agreement on Tariffs and Trade |
| GDP | gross domestic product |
| GEF | Global Environmental Facility |
| GEMI | Global Environmental Management Initiative |
| GPS | Global Positioning System |
| gWh | gigawatt-hour |
| HC | hydrocarbon |
| HCFC | hydrochlorofluorocarbon ("soft" CFC—partially chlorinated, and less damaging to the ozone) |

| | |
|---|---|
| HCl | hydrochloric acid |
| $H_2O$ | water |
| IDA | International Development Agency |
| IPCC | Intergovernmental Panel on Climate Change |
| ITQ | individual transferable (fishing) quota |
| kWh | kilowatt-hour |
| LEV | low-emission vehicle |
| MBI | market-based instrument |
| MEY | maximum economic yield |
| MSY | maximum sustainable yield |
| MTBE | methyl *tert*-butyl ether |
| mWh | megawatt-hour |
| NAFTA | North American Free Trade Agreement |
| NGO | nongovernmental organization |
| $NO_x$ | nitrogen oxides |
| NPSP | nonpoint-source pollution |
| $O_2$ | oxygen |
| ODS | ozone-depleting substance |
| OECD | Organisation for Economic Co-operation and Development |
| OTC | Ozone Transport Committee |
| PCB | polychlororinated biphenyl (a persistent organic chemical) |
| PM | particulate matter |
| ppm | parts per million |
| REP | refunded emissions payment |
| SEPA | Swedish Environmental Protection Agency |
| Sida | Swedish International Development Cooperation Agency |
| SIP | state implementation plan |
| SKr | krona (Swedish currency; 10 SKr ≈ US$1) |
| $SO_x$ | sulfur oxides |
| TAC | total allowable catch |
| TCE | trichloroethylene |
| TEP | tradable emissions permit |
| TRI | Toxics Release Inventory (United States) |
| TSPs | total suspended particles |
| UAE | United Arab Emirates |
| UNDP | United Nations Development Programme |
| UNEP | United Nations Environment Programme |
| UNFCCC | United Nations Framework Convention on Climate Change |
| VA | voluntary agreement |
| VOC | volatile organic compound |
| WHO | World Health Organization |
| WTO | World Trade Organization |

# *Policy Instruments for Environmental and Natural Resource Management*

CHAPTER 1

# *Background and Overview*

IN AUTUMN 1999, the United Nations announced that the human population had reached 6 billion individuals. It is not clear whether this announcement was a cause for celebration or alarm.

Global population is growing fast—almost 80 million people per year—and has doubled since 1960. Most of that growth is in poor countries. India's population has passed 1 billion, and India may become the world's most populous nation within a few decades. Recent projections indicate that the rate of growth is slowing somewhat, but world population is still projected to reach 9 billion within a few decades. This population growth poses considerable challenges for resource and environmental management.

## Definitions, Concepts, and Challenges for Policymaking

The links among population, poverty, growth, resources, and environment are complex, and the mechanisms that determine human fertility and mortality (and thereby population dynamics) are an interesting topic of study.[1] The harsh-but-effective Chinese policy has shown the world that policy mechanisms can affect human fertility and mortality, but can population growth be affected by policies that do not infringe so heavily on personal liberties?

Interestingly enough, population growth appears to be decreasing quickly in most countries. The global average number of children per woman has fallen from about 6 in 1950 to 2.9 in the 1990s. In the richer countries, fertility is typically around 2 children per woman, which means that population will stabilize or in fact slowly decline. Income and education are particularly important determinants of fertility, and thus "development" automatically brings some decrease. The speed of transition depends on many cultural and institutional factors that may lock countries into a form of "demographic trap" in which poverty is both cause and effect of fast population growth. Results of

studies exploring the links among institutions such as property, marriage, and inheritance law as well as the more subtle cultural determinants of fertility indicate that policies can and do have a large effect on household decisions, such as whether to marry and how many children to have (Dasgupta 1993). This finding indicates that policymakers may be able to successfully affect the fertility issue, but the sociocultural and personal aspects of fertility and mortality make it a difficult area for policy application.

Besides population, other major determinants of human impact on ecosystems are level of consumption and choice of technology. This concept is neatly summarized by the $I = PAT$ equation, whereby impact depends on population, affluence, and technology (Ehrlich and Holdren 1971).

### *Market Failures*

One frustration of many environmentalists is that seemingly simple solutions to serious environmental problems exist but are never implemented. In this book, I write about policy instruments that are designed to ensure implementation. To begin, policymakers must understand why environmental policy is needed. The reasons include market and policy failures that are interlinked with the evolution of property rights.

*Market failure* is a technical term that roughly refers to conditions under which the free market does not produce optimal welfare. It is thus a "failure" compared with the abstract model economists make of a perfect market economy. Important examples of such failure include external effects (externalities), public goods, common pool resources, poorly defined or defended property rights, noncompetitive markets, and imperfect (or asymmetric) information. *Policy failure* may appear to be a simpler concept, but a seemingly neutral concept of welfare underlies it. Policies reflect economic interests, and in some cases, there may not be a single policy that is "optimal" for every group in society. One can sometimes distinguish between corrupt policy and bad policy. The corrupt policy is one that claims to be in the interest of the whole country but actually serves the interest of one group (and may actually do that very successfully). A bad policy is one that intends to enhance welfare in a reasonable way but fails due to ineptitude. Property rights are institutions that can be affected by policy, although the process is typically very slow.

*Externalities* are nonmarket side effects of production or consumption, such as soil erosion caused by unsuitable agricultural practices (particularly on hillside slopes). The silting of dams and the destruction of coral reefs are real costs, but these costs are not borne by the individuals or corporations that cause the damage. Such situations can be seen as consequences of incomplete property rights: if waterways had owners with a right to clean water, then those owners could sue those who caused the soil erosion and thus internalize the effects.

*Public goods* are products or services that are enjoyed in common, such as defense and air (clean or dirty). The market tends to undersupply these goods because it is hard to exclude those who do not pay. Instead, political processes are needed, such as the election of a government that collects taxes and finances public goods. *Common pool resources* also have costly exclusion, but the goods pro-

duced with these resources are consumed individually (as *private goods*). Examples include firewood and fodder, and the resources are often managed as *common property.* Free riding and other mechanisms that lead to the undersupply of public goods may also lead to the overuse of common pool resources unless institutions are strong enough to limit access by the users. *Noncompetitive markets,* monopolies, and oligopolies usually result in nonoptimal supply (e.g., too little may be sold at too high a price).

Of all the market failures, *asymmetric information* is perhaps the most pervasive. Economists typically point out that there are no "free lunches" yet commonly assume that information is freely available to everyone. Information is costly, and lack of information stops the market from operating perfectly. Understanding information asymmetries not only helps us design policy instruments to address monitoring difficulties; it also goes to the heart of the most essential dilemma: how to promote social goals such as equity without destroying incentives for work and efficiency. Because policymakers do not have reliable data on pollution damages and abatement costs, for instance, they cannot design policies that are both efficient (with respect to resource allocation) and fair (in sharing the burdens of all the costs involved). If policymakers need the cooperation of individuals who have "inside" information, then they must accept that those individuals may be able to earn something in return for disclosing information.

### *Social Rights and Norms Concerning Nature*

The concept of *environmental problems* sounds simple enough, and depending on one's background, it may bring to mind issues such as factory smoke, soil erosion, and dam siltation. However, at a deeper level, the concept is difficult to comprehend because it touches on the relationship not only between human beings but also between humans and nature.

To determine what an environmental problem is and what needs to be remedied, policymakers must understand not only technology and ecology but also the sociology, economics, and politics of property rights. Rights, policy instruments, and politics are interlinked in ways that vary between economies, and information also plays a pervasive role. One everyday illustration of rights is cigarette smoking.

A few decades ago, individuals had the right to smoke almost wherever they pleased. People who suffered from the effects of secondhand smoke had no alternative but to try to avoid smokers. Over time, increased information and other factors have changed this situation so much that today, in some countries, the rights have been reversed: individuals have the right to enjoy a smoke-free environment. This sea change has permeated even the private sphere, so smokers visiting private homes kindly ask permission to smoke, or they simply go outside before lighting up. The use of instruments such as no-smoking zones, tobacco taxes, prohibition of tobacco advertising, and legal suits against the tobacco companies has strongly affected the general perception of rights regarding cigarette smoking. Whereas some policy instruments are only possible thanks to changes in individual rights, instruments also can help to change the structure of rights by changing moral and ethical perceptions.

### *Current Problems and Warning Signals*

A few examples illustrate the kinds of problems that face humanity:

- Earth's protective stratospheric ozone layer has been degraded by the emission of toxic synthetic chemicals into the air.
- Synthetic chemicals and toxic metals have spread to the supposedly most inaccessible corners of the planet, including the Antarctic; some have accumulated in the food chain and have penetrated the genetic makeup of the human population.
- Already in the 1980s, human activities used about 40% of the primary energy transformation through photosynthesis, which is the basis of all life on Earth. This consumption level does not leave much for natural ecosystems and biodiversity (Vitousek et al. 1986, 1997). Energy consumption, especially of fossil fuels, poses threats at local and global levels. Its potential effects on climate are a topic of international concern.
- Water scarcity is a threat to agriculture and consumers in many countries. The level of some of the world's major waterways (e.g., Nile, Indus, Ganges, Colorado, and Yellow Rivers and the Aral Sea) has fallen visibly as a result of industrial, agricultural, and residential use, and water tables in many regions of the United States, India, China, and other countries are being drawn down rapidly.
- Soil degradation, loss of forest cover, and threats to the marine and coastal ecosystems (e.g., mangroves and coral reefs) have created considerable risk to biodiversity as well as to the sustainability of the food chain.
- Yields of many of the world's fisheries are decreasing. To keep up catches, earnings, and employment, fishermen have stepped up efforts by using larger boats, nets with smaller mesh, and sophisticated technologies such as sonar and satellite navigation. Instead of encouraging restraint, many policies "help" the fishermen by subsidizing the purchase of boats and technology, thus lowering costs to fishermen and increasing the overall fishing effort—thus exacerbating the problem rather than resolving it.
- The energy crisis of the 1970s spurred research into technologies for saving energy (e.g., fluorescent lighting, heat pumps, "hypercars," and thyristors) and for alternative methods of producing energy (e.g., wind power, solar power, and biofuels); good technologies have been developed for efficient energy use in transportation, lighting, heating, and industrial processes. However, sometimes the consumer price of energy is too low to make the alternative technology commercially viable. External costs related to local and global environmental problems (e.g., health and productivity costs of getting asthma and bronchitis in urban areas) usually are not included as part of the cost of electricity or gasoline. If consumers were required to pay the real total cost of energy, they would be more motivated to adopt energy-efficient techniques.
- People whose livelihood depends on natural resources (e.g., grazing lands) typically know their resources well and would have the knowledge to manage those resources rationally, even optimally, if given the opportunity and the means. However, absolute poverty makes the risk of variations in yield unacceptable and can result in unsustainable behavior. Instead of investing in new

productive and sustainable technology, for example, poor individuals might continue to use methods that damage the ecosystem. These methods may be individually rational adaptations that fill the place of missing markets or institutions for savings and insurance, thus showing the detrimental effect of this market failure.

- The income and equity aspects of environmental issues and policy instrument design are often crucial. Imposing taxes to reduce herd size, overfishing, or vehicular traffic can solve congestion and overuse problems but may still be resisted because they leave the users with less welfare if the taxes collected are siphoned off for purposes that are perceived as unproductive for the local users. Policy instruments must give local users a price signal that internalizes externalities without transferring the money out of the local community. There are numerous ways of doing this—for example, through permits that are allocated freely to local users, or by levying charges rather than taxes and then using the charges for local environmental or resource funds, which then can be allocated locally. Many environmental fees in developing countries operate in this way (see Chapter 24).
- In many instances where environmental policy is warranted, polluters have more information and typically greater resources at their disposal than the policymakers do; informational instruments may be an important first step toward successful policy. By collecting and disseminating information, an agency can create a baseline for future action; encourage transparency in implementation, so that individual inspectors cannot "make deals" with polluters outside the law; and clear the way to inform and empower customers, workers, investors, neighbors, and other concerned groups (see Chapter 24).

### *Applying Theory to Nature*

*Environmental economics* (or *ecological economics*[2]) addresses the interface between economics and the life support system of Earth. *Natural resources economics* addresses both geological resources such as oil and minerals and, increasingly, biological resources such as forests and fisheries. It can be considered an integral part of environmental economics, even though it often is treated as a separate discipline. To take advantage of the lessons that these two areas can provide for each other, I discuss them jointly as far as possible. Environmental policy is interdisciplinary; although economic theory can make a fundamental contribution to the understanding of policy instruments, it can do so only in conjunction with natural science, technology, and other social sciences.

Some people doubt that the conventional paradigm is forceful enough to manage the many serious environmental problems that now face global society, but an increasing number of powerful policy instruments are now available in the conventional tool kit: taxes, charges, permits, deposit–refund systems, labeling schemes, and other information provision systems. The main problem is that these instruments are rarely used properly. Historical examples of serious attempts at environmental policymaking are quite rare. Rather than worry about whether the available policy instruments will ultimately be sufficient, policymakers should make larger scale use of them.

In attempts to avert ecological disasters, policymakers must remember that "disaster" is already an apt description of everyday life for many people in developing countries. Many of the problems that low-income people face are deeply intertwined with the degradation of natural resources and, in some cases, the spread of pollution. Policymakers must focus on the interaction between poverty and ecosystem resources and take particular care to study the distributional characteristics of environmental and resource issues, especially of proposed policy instruments.

Many developing countries lack the resources needed to implement ideal market-based instruments; for the same reason, they also lack the ability to manage other policy instruments. (Regulations need monitoring, enforcement, and occasionally sanctions, which are not necessarily easier to implement than taxes.) At the same time, the welfare effects of environmental degradation can be the worst and the urgency of economic efficiency the greatest in developing countries. The selection and design of policy instruments is more complicated and more important in developing than in developed countries.

A body of scientific analysis on policy instruments already exists. The many references in this book are only a sample of the available literature. Much of this work concentrates on one issue or aspect at a time and tends to be written for specialists; the seminal article by Weitzman (1974) is a fine example. Other work includes the popular textbook by Baumol and Oates (1988). Tietenberg wrote a series of empirical and conceptual analyses (e.g., Tietenberg 1990), and Xepapadeas (1997) wrote a recent theoretical book of great clarity. Other central works on instrument selection include that by Bohm and Russell (1997) (see also Supplemental Reading).

There is also a specialized literature on environmental policymaking in developing countries. Several important contributions stem from the Harvard Institute for International Development (e.g., Panayotou 1998; Vincent et al. 1997). The World Bank (2000) provides an exciting summary and discussion of many new policy initiatives that its research department has been following and, in some cases, fostering. The authors of such books commonly are either proponents or strong skeptics of "economic" policy instruments in developing countries. To some extent, this debate may center on whether the glass is half-full or half-empty. However, one should not be too quick to reach general conclusions about which type of instrument is best suited. Choices should be made carefully, on a case-by-case basis.

## Overview of the Book

Parts One to Three comprise the theoretical portion of the book, defining the need for policy instruments, reviewing the policy instruments available, and discussing the selection of policy instruments under various conditions, respectively. Parts Four to Six illustrate the theoretical concepts by looking at instrument choice and design for road transportation, industrial pollution, and natural resources management, respectively.

### *Part One*

Chapter 2 presents the classical issues of growth, welfare reform, market failure, and externalities. Chapter 3 is a discussion of public goods, congestion, and asymmetric information and uncertainty. Some of this material is traditional public economics and may be familiar to economists, who may want to skim this part as an introduction. An understanding of public economics is essential to seeing environmental policymaking as one kind of public policy reform. Chapter 4 addresses intertemporal, spatial, and ecological complexities that are sometimes underestimated in applying economic models to environmental policymaking. Chapter 5 treats the evolution of rights, which is fundamental to the functioning of markets, the existence of market failures, and the design of market reform.

### *Part Two*

The main role of Part Two is to illustrate the range of available policy instruments and how they operate. Its starting point is the *policy matrix* that organizes information about various policy instruments and their applications in different areas. Direct regulation is presented in Chapter 6. Other instruments discussed include permits (Chapter 7), taxes (Chapter 8), and subsidies and other instruments (Chapter 9). Details in instrument design are important, so I differentiate kinds of permits depending on how they are allocated. Charges that are refunded to the polluters are treated separately, because they result in a different distribution of the cost burden, and thus the politics of implementation changes. Chapter 10 interprets the notion of "instrument" in a broad sense, including common property resource management and the creation of property rights in general, and Chapter 11 shows how legal, informational, and political instruments are affected by local factors in developing national policy and the building of appropriate institutions.

### *Part Three*

Part Three concerns the selection and design of instruments. Chapter 12 focuses on the efficiency of policy instruments under different conditions concerning abatement and cost curves, the character of technical progress, and so on. Chapter 13 examines the role of uncertainty and information asymmetry. The next few chapters present economy-wide (general equilibrium) effects (Chapter 14), effects that are related to income distribution (Chapter 15), and effects of property rights, politics, culture, and psychology on instrument selection (Chapter 16). Chapter 17 is a discussion of international aspects and interaction between policies, and Chapter 18 synthesizes the information presented in Part Three for application to policy design.

### *Part Four*

Part Four concerns the road transportation sector. The environmental damage caused by transportation is presented in Chapter 19, including a discussion of the

damage function related to each mile of driving. In Chapter 20, I describe environmentally differentiated road pricing as the corresponding "first-best" policy instrument. Chapter 21 turns to the "second-best" policy instruments that are used, which range from regulations and fuel taxes to some fairly advanced road-pricing schemes. Chapter 22 addresses the issues of fuel quality, including the phaseout of lead from gasoline, vehicle inspection and maintenance programs, and urban planning in developing-country cities. Chapter 23 is a collection of lessons learned from policy experience in road transportation.

### *Part Five*

The focus of Part Five is the design of policy instruments for industrial pollution. Chapter 24 recounts the experience of developed countries (mainly those in the Organisation for Economic Co-operation and Development [OECD]), comparing taxes and permits for acidifying emissions and comparing regulation, prohibition, taxation, and information provision for hazardous chemicals. Global issues related to CFCs (chlorofluorocarbons) and climate change are discussed briefly. Chapter 25 focuses on the experience of developing and transitional countries. Taxes and differentiated tariffs are important, but the focus is on the use of the tax proceeds and on distributional effects. Voluntary agreements and information provision are prominent instruments, whereas monitoring, funding, and the building of institutional capacity in the environmental protection agencies are fundamental concerns or constraints for policymakers.

### *Part Six*

The overarching theme of Part Six is the management of natural resources and ecosystems: water (Chapter 26), waste (Chapter 27), fisheries (Chapter 28), agriculture (Chapter 29), forests (Chapter 30), and ecosystem services (Chapter 31). These issues are of the greatest significance to people and countries with low incomes, because natural resources can be the main source of livelihood and future prospects for people in countries that have little industry. However, the underlying technology and science is complex and often poorly understood, and many categories of users have fairly insecure or unclear rights highlighting the importance for welfare of distributional issues. In addition, the political and cultural setting can be complex and conflictive.

The text ends with Chapter 32, which attempts to summarize some of the main issues of environmental policymaking and their potential solutions.

### *Additional Materials*

Even though abbreviations are defined in the text, a list of common and technical abbreviations appears toward the front of the book. Because readers of this book come from different academic backgrounds, Supplemental Reading lists are provided at the end of most chapters. The comprehensive References list toward the end of the book includes full citations of the bibliographical references cited in text as well as the Supplemental Reading listings.

## Supplemental Reading

**Environmental Economics and Policy**
Dasgupta and Mäler 2000
Freeman 1993
Hanley, Shogren, and White 1997
Kolstad 2000b

**Environmental Policymaking in Industrializing Countries**
Aaltonen 1998
Anderson 1990
Blackman and Harrington 2000
Bluffstone and Larson 1997
Ekins 1999
Eskeland and Jimenez 1992
Huber, Ruitenbeek, and Seroa da Motta 1997
Lvovsky 1996
Seroa da Motta, Huber, and Ruitenbeek 1999

**Global Climate Change**
Climate Strategies 2002
Toman 2001
UNFCCC 2002

**Relationship between Population and Resources**
Dasgupta 2000
Jodha 1988, 1998

**Selection of Policy Instruments**
Dijkstra 1999
Nordic Council of Ministers 1999
OECD 1989
Russell and Powell 1996
Stavins 2001
Sterner 1994
U.S. EPA 2001

## Notes

1. The most important link is perhaps between the environment and the number of rich people, who consume more and thus exert more pressure on the ecosystem. This effect is sometimes referred to as an *ecological footprint*. It has been estimated that if 6 billion people were to enjoy a North American standard of life, then the equivalent of another two planets would be needed to meet the demand for resources (Rees and Wackernagel 1994). This eye-opening observation can be misleading because it assumes constant technology, whereas the ecological impact of economic activity depends crucially on technical progress. In other words, many extra planets would already be needed to meet current consumption if the technologies prevalent 50 years ago were still in use.

2. Ecologists and natural scientists tend to call themselves "ecological" economists, whereas economists appear to prefer the term "environmental." For some researchers, there is an ideological difference between the terms, which are not identical but do overlap strongly; the distinction is not emphasized here.

PART ONE

# *The Need for Environmental and Natural Resource Policy*

THE FIRST PART OF THIS BOOK IS DEDICATED TO explaining why there are environmental and natural resources problems. This task is not as trivial as it may sound, because there are many potential answers. In fact, a term like "environmental problem" is really a misnomer. It is not the environment that creates problems for society but society that creates problems for itself by not understanding how to interact with the environment. To address these issues, a chemist or physicist might concentrate on the spread of certain compounds, whereas an ecotoxicologist might analyze the resilience of an ecosystem to certain disturbances, a social scientist might study laws and norms, and an architect might be concerned with town planning. Each of these viewpoints contributes a vital element to our collective understanding.

In the next four chapters, I concentrate on conveying how economists address environmental and natural resources problems, starting in Chapter 2 with the most important concept, that of market failure. Economists generally believe that markets can be very efficient at allocating resources, but under many conditions, their attractive efficiency actually breaks down. In the area of the environment, this scenario is unfortunately common; therefore, it is important to consider very carefully what role markets can play and how their efficiency in allocation and their fairness in distribution can be enhanced by policymaking. Chapter 3 reviews the economics of public policy and information. Chapter 4 focuses on adapting economic models to the complexity of ecosystems, and Chapter 5 discusses the evolution of property rights to ecosystem resources.

## Consequences of Economic Growth

The debate on the consequences of economic growth for humanity dates back at least to Thomas Malthus (1766–1834), who prophesied that population would

grow exponentially and resources would be constant or grow more slowly (linearly), so that people would be doomed to live in poverty (Malthus 1803). More recently, the Club of Rome researchers (often referred to as "modern Malthusians") have warned that even the current population and economic activity on Earth is unsustainable.

The first Club of Rome report discussed shortages for such vital metals as lead and mercury that have not materialized (Meadows et al. 1972). Today, there is widespread concern about the toxicity of these chemicals and their abundance in the ecosystems, not their scarcity. This example illustrates an important economic mechanism: with market prices, tendencies toward a shortage—or increased demand that could lead to a shortage—tend to raise the price, which leads to substitution away from that particular commodity and increased resources spent on discovery and developing alternative supplies. To date, this mechanism appears to have been sufficient to avoid shortages of lead and mercury. However, the mere existence of this mechanism does not negate the importance of a country's carefully considering how to manage its natural resources to give maximum benefit, which includes formulating contracts with contractors, designing regulations, and determining resource rents.

The fact that the Club of Rome researchers were wrong about the supply of certain minerals does not mean that they will be wrong about ecosystems in general. In the realm of renewable resources (e.g., fisheries, forestry, water, and agriculture), overuse is a real possibility because of the combination of complicated ecology and inappropriate property management systems. Poor countries must develop policies that both bring about economic growth and address environmental concerns (World Commission on Environment and Development 1987). Global environmental threats include climate change, ozone layer depletion, acidification (of lakes, forests, and more), and the spread of both synthetic (human-made) chemicals and toxic elements from the geosphere into the biosphere. Local environmental threats, which often have health effects, include noise, air pollution, unsanitary working conditions, and infectious disease related to poor water and waste management.

Additional environmental issues include natural resource degradation, overfishing, the destruction of forests, damage to marine ecosystems, soil degradation, and overgrazing of commons. Although local in focus, these issues create a global problem in that the resources are essential to the livelihoods of billions of people in communities around the world. These issues also are inextricably related to each other and to other environmental problems in numerous ways: for instance, soil erosion can exacerbate air pollution and water pollution, which affects fishing, recreation, and human health. Intensive agriculture requires pesticides, which may cause ecological damage and human health problems while leading to decreased overall biodiversity (yet another important global issue). Deforestation dramatically increases the damage from hurricanes and other natural disasters.

The above list is by no means exhaustive. Unfortunately, many other environmental and resource problems exist—many of which are still poorly understood, and some of which have not yet been identified.

## Institutional and Policy Failure

Much of Part One is dedicated to the discussion of market failure. However, market failures are not always the most serious threats to ecosystems. Institutions are also imperfect, and one of the most important institutions is government. The monumental failure of state ownership has already been mentioned. The notion that the state is a neutral and perfect agency to enforce the general well-being of society is very naïve.

One example of imperfect government policy is the formerly planned economies of eastern Europe, where the banishment of "short-sighted profit interests" was hailed as an opportunity to implement policies truly geared to maximizing welfare; yet, the policies really achieved the exact opposite goal, partly because of a simplistic application of the Marxist theory that value is created only by labor. By treating natural resources as free goods of no value, the intrinsic value of those resources was, in many cases, effectively destroyed. The Aral Sea is a sad symbol of such policy. More than half of its area is gone. This giant lake has been turned into a poisonous dust bowl as a result of irrigation, poor management, and excessive cotton production. Ships now lie in the sand, many miles from the current shoreline.

Another example of imperfect government policy is fisheries, because the absence of property rights to the sea leads to the risk of a tragedy of open access. It is a case of considerable market failure in which political policies are badly needed, but the wrong policies make matters worse. Subsidies intended to "help" fishermen actually exacerbate the market failure that they are supposed to address.

In the future, the public sector must not be analyzed as if it were a monolith. In reality, *government* is a series of public-sector bodies with distinct structures, motivations, and modes of operation at different levels. Furthermore, governments are not the only institutions that can fail. The family is also an institution at the micro level, and some form of rational division of labor within it (as well as some fair division of proceeds among its members) is often assumed. However, it is not always the case. In many poor communities, men hold a large share of formal rights and power while women and children are effectively dispossessed and exploited within the contexts of their own families. It is not uncommon for the government to exacerbate such tendencies by automatically granting titles to a male "head of household" when traditional rights may have been much more equal, even where agriculture was managed primarily by women.

Some faulty government policies are a real threat to the sustainable use of natural resources and ecosystems, for example, subsidies for goods, services, or practices that cause severe environmental degradation. Such subsidies are so common that many economists (particularly those working with developing countries) rank "subsidy removal" as one of the main instruments of environmental policy. Given this sadly ironic state of affairs, one might expect that this section ought to be one of the longest in this book. However, undoing bad policies is not a new category of policy; rather, it is part of a general process of policy optimization or adjustment.

One possible, and indeed plausible, explanation for the prevalence of bad policy is lack of information or understanding about the ecological, technical, and

economic relationships that are used to choose and design policy instruments. Other explanations stem from the fact that policies are not designed only by altruistic welfare-maximizing policymakers who are free from personal economic or political interests. The truth is, policies are formed by the interplay of conflicting political and economic interests, and a thorough understanding of the political economy of policymaking is required to analyze any set of instruments used in a specific context. In countries where state institutions are weak, the risk of policy capture by various groups is particularly strong. Presumably, the abundance of damaging subsidies for agriculture and industry in developing and developed countries should be seen in this context.

CHAPTER 2

# *Classical Causes of Environmental Degradation*

HOW ARE ENVIRONMENTAL THREATS related to economic development and growth?[1] At one extreme, some researchers claim that growth has already exceeded the sustainable level of activity on Earth (Meadows et al. 1972). At the other extreme, some researchers believe that technical progress will make it possible to meet the demand that will result from increased population and per capita income (Kahn et al. 1976). In some overly simplified analyses, growth is the main culprit, whereas in others, it is the principal panacea for environmental issues. Neither of these simple positions is tenable.

## Growth and the Environment

The essential determinant of environmental stress is not the average rate of growth but the technology used and the composition of growth or of the economy itself. Whereas increased consumption of polluting cars, pesticides, and chemical-intensive products could become a problem for sustainability, increased consumption of music, Internet information, ecotourism, and organically grown food probably would not. However, in a free market economy, the consumers—not the "social planners" or the ecologists—decide the composition of output (and, indirectly, production).

Policymakers can influence the path of the economy by using policy instruments. To do this, they must first understand the fundamental determinants of economic development. A great deal of research has focused on the composition of the economy and its development over time, which is often associated with the environmental Kuznets curves (EKCs). The idea behind EKCs is that with economic growth, emissions typically follow the inverted "U" curve (as illustrated for emissions in Figure 2-1). According to this hypothesis, the early phases of economic growth inevitably imply increased pollution, but as incomes increase, emissions peak and then decline. The curve for the quality of ecosystem resources

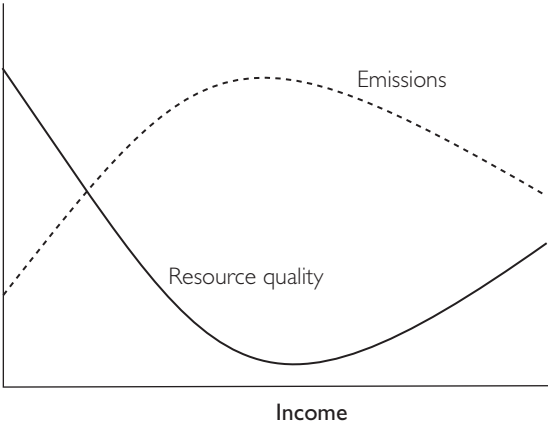


Figure 2-1. *An Environmental Kuznets Curve*

would be the inverse of that for emissions—that is, an upright "U"—signifying deterioration followed by gradual improvement. However, the stock character of these resources complicates the issue.

Explanations for the EKCs concentrate on several general factors, including the development of technology, relative prices, the income elasticity (which describes how demand for goods and services tends to vary with income) for a clean environment, and income distribution. Income distribution also varies with economic growth, as illustrated in the original Kuznets curves (Kuznets 1930), adding another layer of complexity to the relationship between environment and growth.

In fact, the relationship between growth and environment need not take any particular shape. Several functional forms are possible. For some pollutants (in the relevant income range), the curve appears to be a constant increase (e.g., carbon dioxide emissions) or a constant decrease (e.g., bacteria in drinking water). In principle, this difference might result from variations in the turning points of the curves. Thus, it is possible that there is an inverted "U" curve for carbon dioxide emissions, but a constant increase is observed because no countries have yet reached the peak. In such cases, for all practical purposes, EKCs are irrelevant.

EKCs are not inevitable or fixed development paths. The effect of policies may often dominate over the variations described by EKCs, which is encouraging because a strict belief in EKCs would lead policymakers to accept as true that pollution increases were inevitable in the short run. In fact, fairly inexpensive measures often can limit pollution considerably, even in the short run. It would be dangerous if policymakers were to believe that pollution and destruction of natural resources did not matter because the damage would automatically be reversed later, farther along the curve. Experience shows that "repairing" ecosystems and "replacing" natural resources is much more expensive than prevention, and in some cases, the damage is irreversible.

The central recommendations for successful and sustainable development in *World Development Report 1990* (World Bank 1991) include formulating the correct macroeconomic policies, creating a market-friendly orientation, being open to trade, and investing in people through health and education. During the

1990s, many countries were quick to implement a market-friendly orientation and macroeconomic policies (López, Thomas, and Wang 1999). Barriers to trade and finance were broken down; price controls and deficits were reduced. Some countries significantly increased education and health expenditures, and many countries experienced economic growth as well as declining poverty. The 1990s also showed how easily advances in some areas could evaporate into economic crisis and the enormous price (as environmental damage) of economic progress in some countries. It also became strikingly clear that corruption not only is an issue of morals but also entails enormous economic costs (López 2000).

In East Asia and Latin America, openness to trade and knowledge have been important factors in economic growth (Thomas and Wang 1998). An even distribution of human capital, as reflected in the high-quality public education systems in East Asia, is a primary factor behind rapid growth, particularly in conjunction with openness to trade. Global financial integration has implied great benefits for some countries but may imply risks if other economic policies are not appropriate. Despite setbacks in recent years, this rapid growth has been accompanied by rapid decreases in poverty, with a fairly even distribution of income. However, development in East Asia has not been positive for the environment; 9 of the 15 world cities with the worst air pollution are located in East Asia. Some 20% of the vegetated land suffers from soil degradation caused by water logging, erosion, and excessive grazing. Deforestation rates are high, and 50–75% of the coastal areas and protected marine environments are classified as highly threatened (Worldwatch Institute 1996).

Economic growth and environmental sustainability are complex aggregates, determined by the interplay of numerous factors; it would be foolhardy to believe that there is a deterministic relationship between the two. Technology and output composition are important, but these parameters cannot be determined directly;[2] they are determined endogenously in the economy. The composition of output tends to develop in certain ways that reflect factor endowment, tastes, and comparative advantages during certain periods. However, this development results from not an iron law of physics but social behavior, which can be considerably influenced by suitable policies. Similarly, technology choices are made by economic agents and can be highly influenced by suitable policies.

The importance of a good environment for business may be greater than the availability of finance, because the latter will simply come if the conditions are appropriate. A good environment for business is definitely not the same as a good natural environment, but the two parameters are far from contradictory. Of foremost importance for a good business environment appears to be a transparent, predictable, and reasonable legal and political structure. It must be free from corruption and exaggerated bureaucracy but also structured enough to avoid the costly uncertainty of contract enforcement. A good business environment also requires a reasonable natural environment; employees can hardly thrive or be healthy in a deteriorated environment. The distribution of environmental quality is crucial. If the living environment of the poor is so degraded (e.g., through disease or malnutrition) as to inhibit their productive development, then the economy experiences not only a direct decrease in human welfare but also a loss of productive potential.

To reconcile economic freedom, growth and ecological constraints may require a careful blend of policy instruments to influence the composition and the technology of consumption and production (e.g., Carlsson and Lundström 2000). Research and policy experience show that certain policy instruments work better under some circumstances than in others. The choice and design of policy instruments is an important and promising area for future work.

## Welfare and Policy Reform

Economists often assume that the well-being of an individual ($i$) can be expressed as a utility ($U$) function that depends on income, consumption, leisure, working conditions, environment, and other factors. Analogously, it is also often assumed that social welfare ($W$) depends on all these individual utilities, as in the social welfare function $W(U_1, \ldots, U_i, \ldots, U_n)$. Economists typically do not know much about the shape of these functions, but for simplicity, they are sometimes assumed to be linear in the sense that net monetary income would reflect utilities and welfare. Another common assumption is convexity of the functions, which implies that an increase in income for the poor is more important than an increase in income for the rich. Even with general welfare functions, the assumption that economists often make (and that I basically agree with) of the desirability of maximizing welfare still depends on one of several possible value judgments. Other people might prioritize an egalitarian society or a society with some other goals. For most purposes, welfare maximization is still a general goal. The welfare of future generations may be included as well as distributional concerns and concerns about long-run sustainability.

One of the main lessons of economics is that the market mechanism is efficient at allocating resources. Economics attempts to formally illustrate this efficiency by building mathematical models of the economy. Models show that under "perfect" conditions (i.e., a market with free competition and without noncompetitive markets, public goods, or external effects), a market will automatically achieve a (Pareto) optimal outcome. This hypothesis is often referred to as the First Theorem of Welfare Economics.[3] *Pareto optimality* is an efficiency concept that implies that the economic situation of one individual can be improved only if the economic situation of another individual is worsened. Intuitively, this concept can be understood by considering the opposite: that one individual's economic situation could be improved at no expense to anyone else. Most people would agree that this is an unnecessary deprivation. However, even this seemingly technical and neutral efficiency criterion hinges on value judgements. Making one rich person richer (with constant incomes for everyone else) may not be considered desirable. It is thus conceivable that a welfare function would decrease in some individuals' incomes for certain values.

In general, a given economy has many possible optimal outcomes, and different starting conditions (notably, of income distribution) will give different Pareto optima. Choosing between them necessarily requires some value judgement. Criteria are needed to judge the desirability of different states of the economy

that imply gains for some groups but losses for others (e.g., taxing the wealthy to help the poor). Such criteria are an expression of the social welfare function.

The Second Theorem of Welfare Economics states (under fairly restrictive conditions) that any desirable and feasible outcome of the economy that one chooses with the help of a social welfare function can be achieved as the result of a competitive economy. It implies that any outcome can be "decentralized," that is, achieved by the market agents themselves, if the state arranges appropriate conditions (e.g., by a lump-sum redistribution of the initial endowment). It means reallocating money—taking money from some individuals and giving it to others—but otherwise leaving the economy and its mechanisms intact. Such redistributions do not always work in practice (partly because taxes and subsidies influence people's behavior), but in some cases, policy instruments can decentralize the outcome.[4]

A real economy could not be a "pure market" in the absolute sense of having no state interference. The mechanisms that make the market work (e.g., the definition and enforcement of property rights and civil laws that govern contract enforcement) are public goods that have to be provided for by a public body. These and other necessary mechanisms, such as the maintenance of social order and defense, also are costly activities that make at least some level of taxation an inevitable feature of the economy. Taxation requires resources, and its implementation tends to distort the price signals of the market, which modifies the optimal properties that can be derived in a simple and abstract market with no outside interference. As soon as one aspect or area (such as taxation) deviates from the simple textbook model of the "perfect market economy," the conclusions and recommendations from that model may no longer apply. Policies or outcomes that would be best, given that some imperfections already exist, are called "second-best" by economists. Economists' ability to analyze the optimality of second-best situations is limited; however, it is commonplace (and perhaps, on the whole, reasonable) to believe that at least some of the "first-best" efficiency properties of market solutions remain valid; an instrument is "first best" when it would be optimal under some set of ideal (often unrealistic) market conditions, which often implies that the instrument is not optimal in the real (imperfect) world.

The virtual collapse of many formerly planned economies that attempted to rush the transition to the free market without due attention to building the necessary institutions is a good, although unfortunate, illustration of two important facts:

- Economies with an excessive degree of state intervention fail severely in attaining efficiency.
- Economies with an excessively free and unregulated market may fail abysmally on both efficiency and social issues.

Ironically, some economies (e.g., the Russian Federation and other countries of the former Soviet Union) rapidly moved from what could be characterized as "excessive state" to insufficient or perhaps inadequate state institutions. They learned the hard way that the market is a social institution and one that requires considerable enforcement from a state strong enough to defend property rights

and uphold a necessary degree of trust and impartiality in civil law if entrepreneurs are to feel comfortable investing in the economy.

Although neither absolute anarchy nor totalitarian planning has many serious proponents, policymaking is carried out against a backdrop of intense academic and ideological conflict over the optimal extent of state intervention in the economy. The proponents of free markets focus on efficiency as the engine of economic welfare, whereas the advocates of state intervention emphasize that the markets are imperfect without adequate policies to regulate them and to maximize welfare. Preaching the virtue of environmental policymaking is a challenge when the main message among many development economists and macroeconomists is "deregulation and reduced state influence." Consider the Russian experience: economic policymaking need not contradict environmental stewardship. To promote development, it is necessary to eliminate the regulations that stifle growth, not all regulations. In the economic area, a general absence of rules would lead to stagnation; in the ecological area, it could lead to expensive abuse of originally productive resources.

The relative importance of institutions may vary depending on such factors as cultural norms and the characteristics of technology. Less political enforcement may be needed in extremely structured cultures with a tradition of high work ethics and an emphasis on honesty; feedback from economic outcomes and political institutions gradually changes social norms. The institutions needed in an economy where technological progress is slow and labor-intensive will be distinct from those needed in an economy where technological progress is rapid and capital-intensive. Other important factors are the market structure, the size and openness of the economy, and issues related to risk and information asymmetries.

Over the past few decades, the market mechanism has shown its many strengths in real-world economies. The exceptions are nevertheless important, especially as applied to the management of natural resources and ecosystems. This area is characterized by externalities, public goods, common pool resources, imperfect foresight, and other types of market failure. The concern for social welfare implies a special focus on the poor, which in turn tends to imply that risk and uncertainty are given greater weight than maximizing expected return. Variation in income is not an acceptable risk for people who live in danger of starvation; it is far from the "first best" world in which all marginal costs and utilities are equalized.

One particular problem for analysts is the glaring lack of good studies on the efficiency or even the cost-effectiveness of environmental policies.[5] It is important to ensure that public money is used efficiently, but unfortunately, this task is far from simple. Other areas of public spending face the same problem; few good studies report whether a marginal increase in funding of police, military, or intelligence services will be efficient in the sense of optimally promoting public security. Nonetheless, some comparisons are possible, and international comparisons may be the most promising method in many cases.

Considerable literature is available in the area of policy reform. One common problem is that the process of policy reform (e.g., redesigning taxes) changes the relative prices and incomes in a way that makes comparisons with the original state difficult. A successful process of policy reform may well entail taking tempo-

rary steps that are not efficient (Guesnerie 1977). These issues are particularly well illustrated in developing countries, which have large disparities in income (and thus in the marginal utility of money). One empirical study that attempted to design optimal tax reforms for India used a technique referred to as the *inverse optimum,* which entails determining which set of welfare weights would have made the observed state of the economy an optimum (Ahmad and Stern 1984). If the calculated weights do not match the welfare weights that can be assumed for the decisionmaker (especially if they contain weights that are blatantly impossible—such as negative weights for some groups), then tax reform that increases welfare must be possible.

## Market Failure

The conditions under which the welfare theorems hold (i.e., a "perfect market") are convenient analytical abstractions that provide a starting point for economic analysis. A situation in which those theorems fail to hold is called a *market failure* and is very common. In this section, I focus on three kinds of failure: noncompetitive markets, external effects, and public goods.

The idea of a market is that people engage in mutually beneficial trade, and to do so, they must have clear ownership rights and information. In a perfect market, every good and resource has an owner and a price, and the agents have full information of the options available to them. Production and consumption technologies are characterized by the absence of indivisibilities and increasing returns to scale (i.e., the rate at which output changes as the quantities of all inputs are varied)—or, more formally, by the absence of nonconvexities in production and consumption sets. This seemingly technical explanation is illustrated in Figure 2-2.

The intuitive meaning of *convexity* is that you can combine goods (or production inputs) at will within the set of possibilities. This assumption is often taken for granted, and understanding how its absence can render optimality unachievable is simple: suppose that you want to buy bread and cheese, but the smallest package of each is so large that you would have to spend your entire budget on only one item. Although this example sounds trivial, indivisibilities are sufficient to prevent the attainment of optimality. Similarly, the high minimum-efficient scales of refineries or steel mills cause problems in small countries; small plants are not cost-efficient, big plants may have insufficient demand, and no plant means that the country will be 100% dependent on imports. The same applies to infrastructure investments such as bridges, health programs, and railways. A country may desperately need infrastructure but find the available systems excessively large and prohibitively expensive. The absence of intermediate-scale solutions implies constrained choice, and a decentralized market will not lead to an optimum. Such a nonconvexity may be created by increasing returns to scale. It may mean that a project of size $A$ is feasible, but a project one-half the size of $A$ is too expensive.

*Noncompetitive markets* such as monopolies and oligopolies are a kind of market failure that usually leads to excessively low production volume being sold at too high a price. This situation diverges from the optimum because an increase in

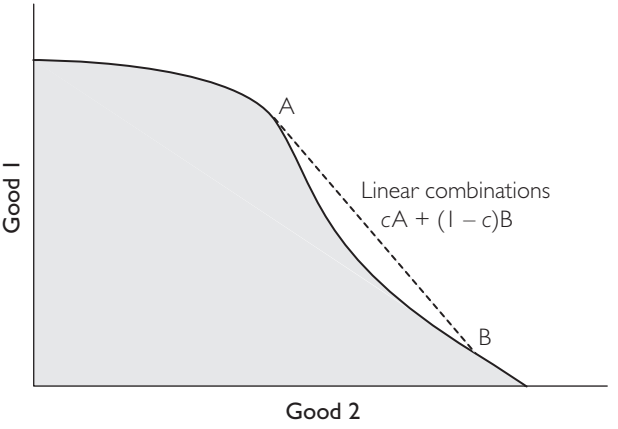


**Figure 2-2.** *Convex Combinations in Consumption Space*

*Note:* Input or consumption bundles *A* and *B* are both feasible, but combinations such as one-half of *A* plus one-half of *B* (or more general linear combinations) are not attainable because of the nonconvexity shown.

production would be possible and would be valued more highly than the additional cost. The existence of monopolies in the economy is partly related to underlying cost structures, such as increasing returns to scale. They are generally accepted as something that policymakers should regulate.

Typically, *external effects* also create this kind of nonconvexity. Consider two goods, *A* and *B,* that have strong negative externalities between them. You can have *A* or *B*, but obtaining both is difficult. Similarly, by definition, *public goods* imply that everyone has to consume the same quantity: there can be one state of the economy in which everyone gets none of the public good and there can be a state in which everyone gets a quantity $z$ of the same good, but there cannot be a state in which some people get none and some get $z$. This restriction, too, means that the decentralized market will not lead to an optimum. Other causes of nonconvexities include common pool resources, congestion, and joint production.

The simplest economic models are deterministic and atemporal, but the real-world economy takes place in real time, and its outcomes are stochastic; the best one can hope for is to know their probability distribution. In general models of the economy, a "space" of goods—each of which is labeled by a probability and a date—can be defined. In such a model, there can be many more sources of nonconvexity, including varying degrees of myopia (nearsightedness), uncertainty, risk aversion among the agents of the economy, and transaction costs.

For a market to be perfect, all property rights must be fully allocated. No externalities, public goods, or other nonconvexities should exist. There also must be markets for all goods and resources, including, most importantly, future goods (i.e., future markets) and full information about all these markets. The mere existence of a market failure does not automatically warrant the implementation of a given policy because the costs of market failures must be weighed against the potential for "policy failures." This comparison must be carried out within the specific context of general policymaking in the economy to be studied (see Chapter 5).

## Externalities

An *externality* can be defined in different ways, but it typically is an unintended and uncompensated side effect of one person's or firm's activities on another. Good examples are the health effects of smoke emissions from vehicles, factories, and cigarettes. These side effects occur because of a technical interdependence in consumption or production (see Box 2-1, Definition of Externality). They are not intentional damage per se, and they typically are difficult to avoid. Note that this interdependence must also be a nonmarket dependence to qualify as an externality. If many people are lined up to buy a good (e.g., medicine or water), the price of which consequently increases, then the effect (commonly referred to as a pecuniary externality) is not an external effect, because it is perpetrated through the market mechanism. If most people in an area take antimalaria drugs and this action ultimately decreases the number of malaria mosquitoes (and thus the malaria risk to individuals who do not take tablets), then people who do not take tablets are the unintended beneficiaries of an external effect.

Another approach to defining *externality* is to suppose that ownership rights or markets are missing for the particular resource in question. For example, if there were private ownership of the air, then people would have to buy the right to pollute it with smoke, and passive smoking would be internalized through the market. Practical barriers to the establishment of such rights and markets, however, are likely.

*Externality* is perhaps the most basic concept in environmental economics. It has long been recognized as a problem but originally was seen as a minor one. The classical economists wrote of the soot from factories in Manchester and Liverpool, England, that dirtied the laundry hanging on the line and of the bees who pollinated neighboring farms' orchards. Sometimes the beauty of a rose garden, enjoyed by not only the owner but also passers-by, was used as an example. These examples

### Box 2-1. Definition of Externality

A general definition of an *externality* is the existence of some variable that enters into the utility or production function of an agent (an individual or a firm *i*) in the economy, although it is controlled by another agent (*j*) who does not take effects on *i* into account and does not pay compensation. For the case of utilities, the utility (*U*) of individual *i* depends not only on his own consumption but also on the consumption (or some other variable) of another individual *j*:

$$U_i = U_i(x_i, x_j) \tag{2-1}$$

One example of this function is second-hand cigarette smoke.

When many agents affect each other, the function can become quite complicated. However, any information about the nature of these functions can be included. For example, if a number of agents ($j = 1, \ldots, m$) emit smoke ($s_j$) and this emitted smoke is perfectly mixed in the atmosphere, then it is the sum of all the smoke ($S = \Sigma s_j$) that affects utility, allowing a simplification of the equation:

$$U_i = U_i(x_i, s_1, s_2, \ldots, s_m) = U_i(x_i, S) \tag{2-2}$$

clarify the issue but also border on triviality. However, the environmental issues that confront us today—contaminated drinking water, smog in developing-world cities, destruction of the ozone layer, acid rain, and global warming—are far from trivial. Unfortunately, the dependencies might be long-ranging, which makes defining property rights or negotiating difficult. Examples include cases in which the polluter and victim are separated by long distances (e.g., the effects of soil erosion on coral reefs) or in time (e.g., the risks posed to future generations by nuclear waste).

## Supplemental Reading

**Environmental Kuznets Curves (EKCs)**
Dinda et al. 2000
*Environment and Development Economics* 1997
Grossman and Krueger 1995
López 1994

**Welfare Economics/Resource Economics**
Arrow 1951
Debreu 1951
Hartwick and Olewiler 1998
Mäler and Vincent 2001

**Policy Reform**
Atkinson and Stiglitz 1972, 1980
Diamond and Mirrlees 1971a, 1971b
Feldstein 1976
Hanemann 1995
Murty and Ray 1989

The environment and the various services provided by ecosystems enter into ordinary production and consumption in ways similar to those of other inputs. Thus, they should be included in economic accounts at corporate and national levels. They often are not, because there is no "owner" or because the environment has the characteristics of common property or a public good. The absence of property rights is related to scarcity. Classical writers such as Marx noted that water might have great "use value" but little "exchange value" when plentiful. Without water, there would be no production and no life, and thus, in a sense, water is "infinitely valuable." In countries where it is abundant, it is practically free. Similar arguments apply to many natural, environmental, and ecosystem resources. Oxygen, phosphorus, DNA, chlorophyll, iron, and biodiversity—to name only a few—are individually infinitely valuable.

Trying to estimate the total value of global ecosystems is pointless because the value is infinite. Only marginal changes can be studied. History shows that property rights and market values appear only when use value is coupled with scarcity. Thus, the existence of external effects is intimately tied to the absence of markets, and this absence, in turn, is the result of a certain social and historic condition. In fact, the absence of property rights or of markets is an alternative way of defining externalities. At one time, there were no rights to land anywhere; today, most land is claimed, and agents are staking out rights to radio waves, geostationary parking slots, genetic codes, and even property lots on the moon. (Property rights are discussed further in Chapter 5.)

Externalities are commonly distinguished as depletable or nondepletable. The manure from horses is a depletable externality because if one person takes it, another cannot. However, the odor of horse manure is a nondepletable externality because one person's exposure does not reduce the exposure to others. (This concept also applies to congestion and is essentially the same as the nonrivalry of public goods.)

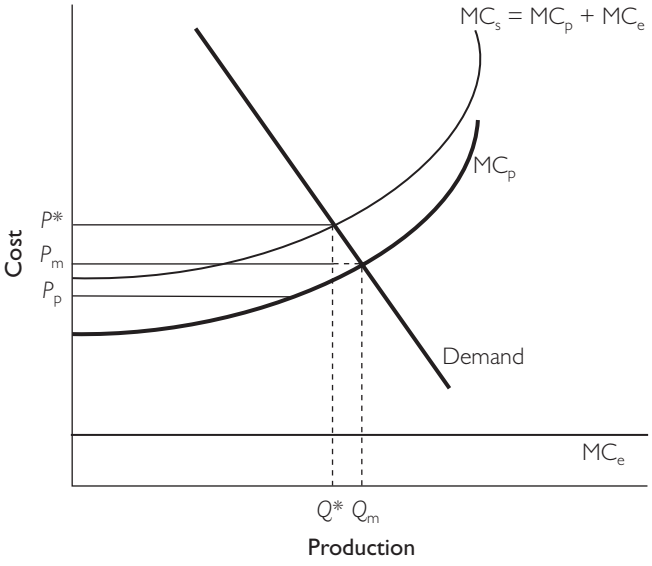


Figure 2-3. *Externalities and Their Effect on Markets*

*Note:* $P$ = price; $Q$ = quantity; MC = marginal cost. Asterisk indicates optimum value. Subscripts m, p, s, and e represent market, private, social, and emissions, respectively.

The effect of externalities on resource allocation is illustrated in Figure 2-3 for production externalities. It shows the usual market analysis for a certain product, with supply determined by ordinary private production costs ($MC_p$). Market equilibrium is determined by the intersection of demand and supply curves ($Q_m$, $P_m$). If each unit of production gives rise to a certain (for the sake of simplicity, constant) external effect, then there is an extra cost to society ($MC_e$) that is not borne by the producer. This damage would be measured as the sum of the decreases in utility due to the external effect for all individuals or firms affected. For individuals, it would be $MC_e = \Sigma_j U'_{ji}$ (i.e., the sum of marginal disutilities for all $j$ of acts carried out by $i$). If internalized, it would be a social marginal cost of production ($MC_s$), $MC_p + MC_e$. The intersection of this curve with the demand curve gives the social optimum ($Q^*$, $P^*$). The analysis is often more complicated, because several production methods give rise to different quantities of externalities. Also, the same physical emissions might cause different amounts of damage, for instance, depending on the location of the pollution source.

## Notes

1. The relationship between these concepts is complex. *Development* is a broad concept that includes both economic growth and other (positive) societal changes, such as the addition of intangible value and maybe a more even distribution of income. *Growth* may mean simply an increase in GDP but ideally should be growth in true income (i.e., including various welfare-

related aspects, such as the environment). For the purposes of this discussion, the meaning approaches the more general concept of development, but the closer it gets, the harder it becomes to measure.

2. Similarly, the distribution of income, the degree of competition, the transparency of decisionmaking, the degree of corruption, and other variables are partly endogenous to economic development but can be influenced by policymaking and then, in turn, have a decisive impact on economic development.

3. Actually, more conditions are required, such as absence of indivisibilities and advantages to scale. More technically, all production and consumption sets must be convex, and all agents must have perfect foresight.

4. The complexities of society sometimes make it impossible to aggregate individual utilities to a social welfare function. If people care about only individual income, it would work. However, if social concerns include altruism, if people have preferences concerning income distribution, or if welfare depends on relative rather than absolute levels of consumption, then the mere construction of aggregate welfare functions may not be feasible.

5. *Cost-effectiveness* means achieving the given goals at least cost. *Efficiency* includes the meaning of cost-effectiveness but also requires that the goals be set optimally with respect to welfare.

CHAPTER 3

# *Public Economics and Information*

THE MOST CLASSICAL OF MARKET FAILURES is the failure to provide public goods that are not consumed by individuals but enjoyed by all or most citizens as a whole. Provision of public goods is one of the fundamental reasons for government. Many natural resources or ecosystem services are at least to some extent "public" in this sense. In order to discuss the implications for policy design, several related kinds of public good must be distinguished, as they are in this chapter.

One of the most important and often neglected "goods" in the economy is information. Information is vital for economic transactions and for market function. Information is sometimes a public good but is often unevenly—or asymmetrically—distributed. Together with the stochasticity of ecosystems and risk aversion among people, asymmetric information can create many serious market failures that have bearing on environmental issues.

## Public Goods, Club Goods, and Common Property

*Public goods* are goods that are used collectively by society. *Pure public goods* are characterized by *nonexcludability* (if a public good is provided for some individuals, others cannot be excluded; e.g., national defense) and *nonrivalry* (the enjoyment of a public good by one individual in no way reduces its availability to others; e.g., television broadcasts). According to public economics, the market alone cannot allocate resources optimally between public goods and private goods; nonexcludability directly invalidates the use of the price mechanism for resource allocation. Affected public goods include defense, law and order, education, and health—even "a clean environment," which can be seen as a kind of public good (and pollution, which might be considered a "public bad").

Because the market does not provide public goods (except in small quantities or special cases, such as when public goods are provided through charity or some

form of sponsoring), the state or some other political body is the origin of collective action that produces them. The most common starting point for a discussion of the optimal provision of public goods is the Samuelson rule, which declares that the social value of a good is equivalent to the combined willingness to pay of (or utility to) all the consumers of that good (Samuelson 1954, 1955) (see Box 3-1). This rule is similar to the one discussed for externalities in Chapter 2. If agent *i*'s consumption somehow leads to a benefit for *j,* then this extra utility will not automatically be considered by *i*—but it should be if social welfare is to be maximized. If everyone enjoys a given public good equally, then the benefit for society is the sum of all the individual utilities. This is an abstract, "first-best" rule for the provision of public goods in a world where, among other conditions, individually differentiated lump-sum taxes are possible, so income distribution is not a variable that must be considered.[1]

In more realistic models, the political and tax systems present various difficulties. For instance, the optimal "second-best" provision of public goods is lower than the first-best because of the cost of raising the tax needed to finance the public goods or the effect of the tax on labor supply. The public sector may have several goals, including an even distribution of income. Such a goal typically complicates models if the distribution of consumption patterns is different for the rich and the poor. When income distribution goals cannot be met by using taxes and subsidies, and if the public good in question is particularly attractive to poor people, then it may be optimal to increase its provision. Similarly, the optimal tax structure for different goods may reflect a mixture of goals: a negative externality related to a particular good is a factor that leads to a higher tax, whereas consumption of that particular good by the poor is usually an argument for a lower tax. The construction of optimal taxes is complex, and the results depend on the model. With some forms of income tax, this contradiction need not arise.

Two other categories of goods are closely related to public goods but often have some degree of congestion (i.e., "costs" are related to the use of a good by many people) and rivalry in use. *Impure public goods* include such seemingly classical public goods as parks and roads, but the utility of one user typically is reduced by an increase in the number of other users. *Club goods* (sometimes called *mixed goods*), categorized between private goods and public goods, can be consumed by many individuals without diminishing the consumption of others (e.g., a movie). However, exclusion (of nonmembers) is possible.

For both of these categories, the first-best Samuelson rule still holds in the sense of Equation 3-2: the club good should be supplied in such a quantity that its price corresponds to the sum of the $n$ club members' marginal willingness to pay. Several interesting issues remain to be solved, such as the number and size of the clubs ($n$). As long as exclusion (of those unwilling to pay the price of the club good) is possible, the decentralized market economy can solve this problem and provide club goods in an efficient manner (Buchanan 1965). Similarly, if people are willing to make trade-offs between the quality of *local public goods* (i.e., goods that are public to a community or municipality) and taxes, then different local communities could offer mixed public goods of different quality and citizens will base their location decisions on the choice between paying higher taxes with more "free" services or lower taxes with fewer such services (Tiebout 1956).