

NBER WORKING PAPER SERIES

BEHAVIORAL AND DISTRIBUTIONAL EFFECTS OF
ENVIRONMENTAL POLICY INTRODUCTION

Carlo Carraro
Gilbert E. Metcalf

Working Paper 7648
<http://www.nber.org/papers/w7648>

NATIONAL BUREAU OF ECONOMIC RESEARCH
1050 Massachusetts Avenue
Cambridge, MA 02138
April 2000

The views expressed herein are those of the authors and do not necessarily reflect those of the National Bureau of Economic Research.

© 2000 by Carlo Carraro and Gilbert E. Metcalf. All rights reserved. Short sections of text, not to exceed two paragraphs, may be quoted without explicit permission provided that full credit, including © notice, is given to the source.

Behavioral and Distributional Effects of Environmental Policy Introduction
Carlo Carraro and Gilbert E. Metcalf
NBER Working Paper No. 7648
April 2000
JEL No. H21, H23

ABSTRACT

This paper summarizes research presented at the FEEM-NBER Conference on the Behavioral and Distributional Effects of Environmental Policy, held in Milan Italy in June 1999.

Carlo Carraro
Department of Economics
University of Venice
San Giobbe 873, Venice, Italy
and FEEM

Gilbert E. Metcalf
Department of Economics
Tufts University
Medford, MA 02155
and NBER
gmetcalf@tufts.edu

Background

In recent years, environmental policymakers have adopted a set of instruments quite different from those usually prescribed in environmental policy textbooks. Economists have traditionally encouraged the use of incentive based instruments in place of command and control regulation. The starting point for a discussion on efficient environmental policy has been the Pigouvian prescription: to set taxes on pollution equal to marginal environmental damages. In recent years, however, economists have come to recognize that the standard Pigouvian prescription needs to be modified in the face of other important economic and political considerations.

The reasons for this modification of the standard Pigouvian prescription can be found in the nature of the environmental problems to be managed. These problems are often characterized by a transnational dimension, by links to other economic issues, and by their interrelationship with several types of economic externalities. All this implies that environmental policy has to be re-designed in order to be effective even in a world where the policymakers may have multiple interrelated targets and an incomplete set of policy instruments.

Some examples may clarify this point. If markets are not perfectly competitive, and if the regulator is unable to restore perfect competitiveness – sometimes because a single regulator does not exist as in the case of multinationals -- then an environmental policy, designed to correct the environmental externalities produced in the imperfectly competitive industry, cannot be the usual “optimal” tax scheme where the tax rate is equal to the social marginal damage produced by the industry. In general, the optimal tax is lower than the

social marginal damage, because the market externality induced by imperfect competition must be taken into account.¹

As another example, if the regulator is concerned about unemployment, capital flows and the location of firms, or distributional considerations across different sectors in the economy, then he may set a tax and mandate the use of the resulting tax revenue in such a way as to identify the optimal tradeoff among multiple objectives (environment, employment, capital stock, economic structure and growth, etc.).²

If the environmental problem is transnational or global, optimal policy design is even more complicated. Trade-offs may be necessary to ensure the adoption of environmental policy tools by all or most countries involved in the management of the environmental problem. Again the standard economic principle which implies the equalization of marginal abatement costs and benefits across countries may not be the “optimal” one.³

It is often argued that environmental policy may induce firms to innovate, either by carrying out more and newer R&D or by adopting existing environmentally benign technology. Even in this case, environmental policy needs to take into account external effects induced by innovation, market distortions in the R&D markets, free-riding incentives induced by R&D spillovers, possible delays in innovation, as well as benefits and costs of R&D cooperation.⁴

Finally, actual policymakers often attach considerably more importance to the distributional impacts of the policy measures that they adopt than they do to issues of efficiency. As a consequence, environmental policy, given the incompleteness of the policy tools that governments have at their disposal, and the presence of multiple externalities, faces the well known trade-off between efficiency and equity.⁵

The departure of actual environmental policy from “optimal” textbook recommendations may be induced also by political constraints. For example, the failure to use environmental taxation in Europe can be explained by objections to new taxes in countries where the tax burden is already quite high. This has to do with the acceptability of policy measures on which a consensus needs to be found. This is also why voluntary environmental agreements seem to have become a widely adopted policy tool in Europe. Even if this tool may not produce the optimal management of a given environmental problem, it may be the only way to achieve some satisfactory results on emission control in some given industries and/or countries.⁶ In other cases, environmental policy is not optimal because it is simpler or less costly in terms of administrative costs to adopt a policy which is built upon existing policies or which is implemented through an existing set of procedures or administrative structures.⁷

The above remarks suggest some common themes. First, environmental policy has to manage new environmental problems in a world in which there are an insufficient number of appropriate policy tools, because of inertia, lack of consensus, or an excessive number of policy targets. Hence, policy analysis inevitably deals with second best worlds and yields second best policy outcomes.

In addition, most environmental problems are closely linked to industrial, trade, and financial problems. Hence, any analysis of these problems should not be carried out by specialists in environmental economists only, but by economists who can integrate environmental economics with public finance, industrial economics, and trade theory, among other fields.

These conclusions led us to design a book in which:

- chapters are written by leading economists who are able to integrate environmental analysis with the analysis of other intertwined economic issues. Hence, we invited experts from public finance, industrial organization, and trade theory in order to increase “leakages” and “transplants” across fields.
- chapters analyze economic and policy problems where distributional issues and multiple market failures inevitably lead to second best policy analyses.

There two other novel features of this book that deserve some comment. First, most chapters adopt a microeconomic, behavioral approach to environmental problems. This is not to say that a macroeconomic analysis of environmental issues, as is presented in most textbooks, is inappropriate. We believe, however, that greater insight on the mechanisms through which environmental policy works to correct externalities can be obtained by looking at the behavioral responses of economic agents to environmental policy initiatives. It is thus possible to single out the economic incentives provided by environmental policy, their impacts on a firm’s strategy, and their distribution across sectors.

A second important feature is the focus on empirical microeconomic analysis. Most chapters not only provide important theoretical advances, but also attempt to validate the theoretical analysis through careful empirical research, which is often carried out on newly constructed data sets.⁸ Hence, this book can be distinguished from other books because of its ability to integrate theoretical and empirical research, environmental economics and environmental policy, behavioral and distributional concerns, and environmental issues within a wide set of economic analytical tools.

The book is the outcome of a fruitful partnership between the NBER and FEEM. In order to prepare this book, a conference was held in Milan Italy in June of 1999, where papers were presented and discussed. Discussants have been asked to prepare written discussions which are also published in this book. These discussions outline directions for future research and can be quite useful to those who might extend and generalize the results presented in the chapters of this book.

The papers published in this volume fall into four broad groups. The first group is concerned with issues that arise in the design and implementation of tax or other market based instruments. The second group of papers addresses compliance cost issues in environmental policy. The third group of papers addresses environmental policy design when trade and development issues are considered. Finally, the last group of papers takes up the issues of incentives, information, and research and development as they affect optimal policy design. As the various categories above suggest, the papers in this volume span a wide range of topics in the area of environmental policy in keeping with the overall design we had in mind when planning the volume.

Taxes and Other Economic Instruments

As noted above, environmental policy is rarely applied in a first-best world in which pollution is the only externality to be corrected, and in which policymakers have all the information which is necessary to implement standard Pigouvian tax schemes. Moreover, distributional concerns and administrative costs may also affect the decision to adopt a given environmental policy instrument. These issues are discussed in depth in the first part of this volume.

Chapter 2 by Don Fullerton, Inkee Hong, and Gilbert E. Metcalf titled, "A Tax on Output of the Polluting Industry is Not a Tax on Pollution: The Importance of Hitting the Target," considers the efficiency implications of imprecisely targeted instruments. While the standard undergraduate environmental economics textbook prescribes the use of Pigouvian taxes on emissions, real world environmental taxes generally tax inputs or outputs that are imperfectly correlated with pollution. Given the practical difficulties in monitoring pollution, it is often administratively less costly to tax inputs or outputs associated with pollution. These goods may already be taxed and are traded in markets making the imposition and collection of a tax relatively straight-forward. The authors calculate optimal tax rates on goods associated with pollution as well as tax rates on pollution itself under different assumptions about the availability and use of different tax instruments. Among other findings, the authors confirm the result that the optimal tax rate on emissions in the presence of pre-existing taxes on other goods or factors is less than the social marginal damages of pollution, the level prescribed by Pigou (1932) in his classic analysis of pollution taxes. The authors also consider the relative gains from changes in either pollution or output taxes and find that the welfare gain from increasing output taxes is roughly half of the welfare gains from a comparable increase in a tax on pollution itself.

Distributional concerns and their impact on the optimal environmental policy are at the heart of Chapter 3 by A. Lans Bovenberg and Lawrence H. Goulder, titled "Neutralizing the Adverse Industry Impacts of CO₂ Abatement Policies: What Does It Cost?". One of the significant obstacles to any major tax reform or new tax initiative is the existence of windfall gains and losses that accrue to different industry sectors. This concern has manifested itself in the construction of a market for tradable permits for SO₂ emissions in the 1990 Clean Air Act

Amendments in the United States. During the debate leading up to this new law, an important question was whether firms should be given the permits (grandfathered) or should be sold the permits. Bovenberg and Goulder draw attention to the possibility of an intermediate position in which some of the permits are given and the remainder sold. Given the large potential of any CO₂ policy to generate industry rents (windfall profits), the authors find that only a small fraction of emissions permits need be grandfathered to preserve profits and equity values for a firm. CGE simulations that the authors run suggest that the most affected industries (coal, oil & gas) need have no more than 15 percent of their permits grandfathered to preserve profits and equity values.

In the context of an emissions tax, only a small fraction of the emissions need be exempted from taxation. The authors also point out the large difference between preserving a firm's profits and preserving its tax payments. Since a large fraction of the carbon tax burden is shifted forward to consumers, compensating firms for the taxes they owe (the statutory burden) will overcompensate them (relative to the economic burden of the tax). Bovenberg and Goulder carry out a variety of simulations in a CGE model to consider a full range of possible policy plans with their corresponding incidence effects across industries. The key finding – that potential rents are large relative to profits in the absence of regulation and so grandfathering a small fraction of permits suffices to compensate firms for their losses – holds generally in their model.

A frequent obstacle to the introduction of efficient environmental policies is the presence of relevant administrative costs. Chapter 4 by Sjak Smulders and Herman Vollebergh is titled "Green Taxes and Administrative Costs: The Case of Carbon Taxation." Smulders and Vollebergh explore the tradeoff between efficiency and administrative costs in

the design of environmental tax instruments with a particular focus on carbon taxes in Europe. As emphasized by Fullerton and Metcalf, emissions taxes are more efficient than output or input taxes which only indirectly tax emissions. Smulders and Vollebergh focus more sharply in this chapter on the specific administrative costs that arise in the construction and operation of a pollution tax system. In addition, they allow for a continuum of policy choices between the use of emission taxes and product or input taxes.

Smulders and Vollebergh note that where emissions are closely linked to inputs (or outputs), abatement possibilities are few, and if administrative costs of emission taxes are high, then emission taxes should not be implemented. Those conditions precisely apply to carbon emissions and the current tax treatment of carbon in several European countries. The carbon content of fuels is relatively fixed for each fuel type and carbon scrubbing is very costly with current technologies. Moreover, carbon taxes can build on an extensive system of energy taxation and so does not require a large new collection system to be developed. This "piggy-backing" can lead to considerable administrative cost savings. The authors then go on to examine current carbon taxation in various European countries to investigate the extent to which the taxes have been optimally implemented. They find that there is considerable scope for broadening the tax base for the carbon tax at little additional administrative cost.

Compliance Costs

Environmental policy often gives rise to substantial compliance costs. This is an argument raised by companies and industrial lobbies to oppose environmental regulation and policy, often by threatening to re-locate their industrial plants in countries where compliance costs are lower. To assess the validity of this argument, it is crucial to define a correct methodology to quantify compliance costs. Only then is it possible to analyze the impact that

compliance costs have on the investment decisions of domestic and foreign firms. This is done by the second group of papers of this volume.

In Chapter 5 titled "An Industry-Adjusted Index of State Environmental Regulatory Stringency," Arik Levinson, constructs an index of state level environmental regulatory stringency from 1977 to 1994 across the 50 states in the United States. The index has a number of advantages over existing indices of environmental regulation. Previous measures were often subjective and simple cross sectional measures which made analysis of trends across time and states impossible to carry out. Moreover, Levinson notes that the indices ignore differences in industrial composition across states. Ignoring industrial composition means that states with a heavy concentration of pollution intensive industry will show up as a highly regulated state (as measured by costs of compliance) regardless of the state's regulatory structure. Levinson's measure explicitly controls for industrial composition. After constructing the measure, Levinson applies it to an analysis of foreign direct investment in the United States. He finds that the index performs better than other measures of regulatory stringency in measuring the impact of environmental policy on FDI.

Chapter 6 by Randy Becker and J. Vernon Henderson is titled "Costs of Air Quality Regulation," and investigates the role of air quality regulations in the United States on capital investment as well as the cost structure of firms. For the past twenty years, each county in the United States has been designated as in or out of attainment with the National Ambient Air Quality Standards for ground-level ozone (O_3). Firms in non-attainment areas are subject to stricter scrutiny and regulation than are firms in attainment areas and the contrast between investment behavior in non-attainment versus attainment areas can serve to identify the impact of environmental policy on firm investment. The identification process is confounded,

however, by the fact that firms can self-select into or out of non-attainment areas and Becker and Henderson pay careful attention to the endogeneity of firm behavior. Focusing on the industrial organic chemical and miscellaneous plastic parts industries – major emitters of volatile organic compounds and nitrogen oxides – the authors find that the stricter regulation in non-attainment areas leads to greater amounts of up-front investment in those areas but lower overall size in mature firms. The large up-front fixed costs associated with the permitting process for construction of new plants makes it efficient for firms to increase their initial plant investment. Moreover, as regulations tighten over time, these plants are grandfathered under the old rules and so avoid increased production costs. Becker and Henderson then look to quantify the regulatory costs by estimating cost functions and comparing cost differences between attainment and non-attainment areas. The cost differences are substantial. Not surprisingly, these cost differences are considerably larger than the costs of pollution abatement estimates from data sets that directly measure pollution abatement investment and costs. Among other things, the latter data sets only measure costs of activities directly and substantially related to pollution abatement and so ignore many of the costs that firms bear in response to regulation.

International Trade and Development

Environmental policy often has an international dimension. This is because environmental problems are often international or even global. But the international dimension of environmental policy is also related to its distributional and behavioral impacts. Indeed, policy decisions taken in one country may affect economic variables in other countries, through their impacts on trade, investment, energy prices, and other economic variables. This may modify both the growth and the distribution of world income (this point

should be obvious if, for example, one thinks of the impacts of past oil shocks). Some of these aspects are taken into account by the papers in the third part of this volume. For instance, the paper by Rauscher extends the analysis of the double dividend question to the case in which international factor movements are explicitly considered in the model,⁹ whereas the paper by Jha and Whalley focuses on the interdependence between environmental policy and income distribution at the world level.

Chapter 7 by Michael Rauscher is titled "International Factor Movements, Environmental Policy, and Double Dividends." Rauscher investigates how the design of environmental policies affects unemployment and welfare in a model with unemployment due to sticky wages. While a fixed wage model ignores the complexities that arise when unemployment is due to a wage bargaining type model, it allows Rauscher to focus on the interactions between unemployment and environmental tax reforms. As in Bovenberg and Goulder's chapter, environmental policy can lead to scarcity rents which accrue to those who employ capital as a factor of production. A tightening of environmental policy raises the scarcity rents, which in turn makes capital more desirable (since the rents are associated with the use of capital). As the demand for capital rises, labor is more productive and firms respond by hiring more workers and so lowering unemployment. Rauscher now considers a variety of environmental tax reforms and measures the impact of this rents effect on unemployment. He finds that this rents-unemployment connection persists in the general equilibrium and that it is possible that tighter environmental policy could in fact attract mobile capital from outside the country and thus lower unemployment. A corollary finding is that a shift from command and control regulation that creates scarcity rents to a tax regime that

allows the government to appropriate those rents could lead to capital flight. How large this effect is remains an empirical question to be answered in future research.

Chapter 8 by Raghendra Jha and John Whalley is titled "The Environmental Regime in Developing Countries." Again the chapter is concerned with distributional issues, but at the international level. Jha and Whalley make a number of points relating to differences in environmental problems and solutions between developing and developed countries. First, they note that environmental problems in developing countries are more typically problems of degradation rather than of pollution. Soil erosion, congestion, and common property resources, for example, create externalities that may dwarf the externalities arising from traditional pollutants. Jha and Whalley argue that to contrast environmental policies in developed and developing countries without taking into account the very different environmental issues is to paint a very misleading picture of the problems and possible solutions. They next point out that measures of the social costs arising from environmental problems are highly misleading if the measures focus on traditional pollutants that are the focus of policy in developed countries. Third, the relation among economic growth, policy reform, and environmental quality may differ considerably between developed and developing countries suggesting that grafting policy responses from developed countries onto developing countries without consideration of the differences between the two regions may be misguided. The authors conclude by arguing that an index of the severity of environmental problems across countries that measures the welfare gain from moving to full internalization of the externalities would work best to transcend the large differences in institutional and economic structure, as well as environmental problems across developed and developing countries.

Information, Incentives, and Environmental R&D

The last group of papers of this volume focuses more deeply on the behavioral effects of environmental policy. In order to assess the effectiveness of different sets of policy instruments, it is important to analyze how these instruments modify firms' strategic incentives to promote their products, to innovate, to invest in R&D, to locate their plants in different countries or regions. The chapters contained in the fourth part of the volume extend previous results by introducing uncertainty and irreversibilities, by allowing for endogenous cooperative environmental R&D among firms in the same industry, and by accounting for the possibility that firms adopt appropriate incentive schemes to increase the environmental performance of their own management.

In chapter 9, titled "The Response of Companies to Information-Based Environmental Policies," Domenico Siniscalco, Stefania Borghini, Marcella Fantini, and Federica Raghieri present some preliminary results from a fascinating new data set on voluntary environmental initiatives at the firm level. These voluntary initiatives range from company environmental reports to environmental audit and management schemes such as the recent ISO 14000 standards. Critics of these policies argue that they are simply public relation schemes to make the companies look environmentally benign. It may be, however, that these types of policies can have real effects given the complex structure of large corporations. Agency theory can help explain why these policies might have real effects. Shareholders care about the value of the company which can be adversely affected by liabilities arising from harmful environmental activities in which the firm may engage. In addition to liability risk, firms can lose valuable goodwill and reputation which in turn can diminish the value of the firm. While shareholders may have a stake in their company engaging in environmentally clean activities,

managers may not share this stake. Voluntary information-based policies can play a role in aligning the two groups' interests. Siniscalco and his co-authors have a unique data set which may allow formal tests of some of the theoretical underpinnings of agency theory associated with these voluntary environmental policies.

Since 1992, Fondazione Eni Enrico Mattei has been collecting data from firms that produce corporate environmental reports. By 1998, about 150 firms have produced these reports. The authors first provide some background information on the firms and the types of reports they prepare and then turn to a data analysis on a number of large firms based in sixteen countries in the petro-chemical, oil and gas, and electric power generation industries. Importantly, the researchers have gathered additional information on the companies' environmental compensation and award schemes for employees as well as economic data for the firms. Their preliminary data analysis suggests that the quality of information provided in these corporate environmental reports has important explanatory power for corporate environmental management. While tentative, their results are compatible with some of the emerging agency theories on voluntary information-based environmental policies. Their empirical analysis suggests that firms which implement some forms of environmental reporting performs better both from an economic and an environmental point of view. Moreover, firms which implement incentive schemes to induce managers to careful environmental reporting achieve better results than the other ones. While these results are quite preliminary, the chapter provides valuable information about the range of information-based activities taken at a large number of important international firms and suggests fruitful research opportunities as this data set grows over time.

Chapter 10 by Anastasios Xepapadeas is titled "Environmental Policy and Firm Behavior: Abatement Investment and Firm Location Decisions Under Uncertainty and Irreversibility." Xepapadeas allows for uncertainty over output prices, environmental policy, and technological parameters as firms consider the optimal level of investment in pollution abatement capital as well as the location of new plants. Investment and relocation costs are in many cases irreversible and optimal decision making takes into account the value of options that are killed by making irreversible investments. Xepapadeas constructs a framework with which policy makers can construct optimal emission taxes and pollution abatement subsidies under a variety of models of uncertainty.

Yannis Katsoulacos, Alistair Ulph, and David Ulph take up the topic of environmental research joint ventures (RJVs) in Chapter 11. Their paper, titled "The Effects of Environmental Policy on the Performance of Environmental RJVs", investigates the optimal amount of investment in research and development related to pollution abatement technologies when firms can form voluntary research joint ventures. From the point of view of firms, RJVs help firms avoid costly duplication of R&D effort. This is beneficial from society's point of view although there is the countervailing loss from possibly slower development of new technologies that can significantly reduce pollution due to the lack of competition. In the context of this model, policy makers have two instruments at their disposal. They can levy environmental taxes which will encourage R&D activity. They can also prohibit the formation of RJVs if they feel that the costs resulting from a slowdown in pollution abatement innovations from RJVs outweighs the benefits of avoiding duplicative investment costs. The authors show that the magnitude of environmental damages that can be

averted through innovations resulting from R&D activity is a critical parameter for understanding whether government should allow or prohibit RJVs.

Conclusions

There are a few lessons that can be learned from the set of papers published in this book. First, in a world in which multiple externalities and market imperfections interact, and in which implementation costs are relevant -- mainly because of information asymmetries -- environmental policy needs to be carefully designed, and is inevitably more complex than the first best policies usually studied in textbooks. In particular, a policy mix formed by environmental and non-environmental policy instruments is often adopted as part of the price paid for political or administrative viability. Second, innovation in policy instrument design is also important for managing new and complex environmental problems. Third, social costs of environmental policy cannot be neglected. There are various strategies through which a regulator can reduce the costs paid by firms and consumers. For example, when designing the environmental policy mix, the regulator can use the possible revenue of environmental taxation to provide incentives to spur economic growth. But the regulator can also adopt low cost economic instruments, i.e. information based policies and incentive schemes, that improve firms environmental performance while minimizing impacts on firm profitability. Alternatively, the regulator can adopt policies to encourage environmental technological cooperation, or policies to discourage firm re-location or capital flight.

The chapters presented in this book suggest that further efforts should be made to analyze the costs and benefits of policy mixes specifically designed to manage new and complex environmental problems. Empirical analyses can be a great help in this matter. Another lesson that can be derived from the chapters of this book is that new empirical

information can be very helpful for assessing the performance and cost of different policy mixes. However, empirical analysis is still at a preliminary stage, particularly in Europe, mainly because reliable and broad data sets on environmental issues are still relatively rare. It is our hope that the research presented in this book will play a part in spurring further empirical work -- both in Europe and North America -- that will extend our understanding of environmental policy design in a second-best world.

References

- Bovenberg, A. Lans. 1997. Environmental Policy, Distortionary Labor Taxation, and Employment: Pollution Taxes and the Double Dividend. In *New Directions in the Economic Theory of the Environment*, ed. Carlo Carraro and Domenico Siniscalco, 69-104. Cambridge: Cambridge University Press.
- Bovenberg, A. Lans. 1999. Green Tax Reforms and the Double Dividend: an Updated Reader's Guide. *International Tax and Public Finance* 6, no. 3: 421-443.
- Carraro, Carlo. 1999a. Environmental Technological Innovation and Diffusion. In *Frontiers of Environmental Economics*, ed. H. Folmer, L. Gabel, S. Gerking, and A. Rose. Cheltenham: Edward Elgar.
- Carraro, Carlo. 1999b. Imperfect Markets and Environmental Policy Instruments. In *Handbook of Environmental and Resource Economics*, ed. J. Van den Bergh, chapter 15. Cheltenham: Edward Elgar.
- Carraro, Carlo, Yannis Katsoulacos, and Anastasios Xepapadeas, eds. 1996. *Environmental Policy and Market Structure*. Dordrecht: Kluwer Academic Publishers.
- Carraro, Carlo, and Domenico Siniscalco, eds. forthcoming. *Global Issues, Sovereign States*. Cambridge: Cambridge University Press.
- Fullerton, Don, and Gilbert E. Metcalf. 1997. *Environmental Controls, Scarcity Rents, and Pre-Existing Distortions*. Cambridge: National Bureau of Economic Research, Working Paper No. 6091.
- Fullerton, Don, and Gilbert E. Metcalf. 1998. Environmental Taxes and the Double Dividend Hypothesis: Did You Really Expect Something For Nothing? *Chicago-Kent Law Review* 73, no. 1: 221-256.
- Pigou, Arthur C. 1932. *The Economics of Welfare*. Fourth ed. London: MacMillan and Co.

Endnotes

¹ The design of environmental policy under imperfect competition is analyzed in several recent theoretical contributions. See Carraro, Katsoulacos, and Xepapadeas (1996) and the survey by Carraro (1999b). See also an analysis of monopolies and optimal environmental taxation in Fullerton and Metcalf (1997).

² The EU proposal of a 50-50 carbon/energy tax to reduce GHGs emissions is an example of a policy instrument which balances environmental effectiveness, distributional burden across sectors, and cross country equitable burden sharing. Another example is provided by the so called Green Tax Reforms and by their attempts to provide both an environmental and an economic benefit (double dividend). A interesting discussion of this problem is in Bovenberg (1997) and Fullerton and Metcalf (1998). A theoretical analysis of environmental policy in the presence of multiple targets is provided by Anastasios Xepapadeas and Michael Rauscher in this book.

³ The design of policy instruments in a world where economic issues are often global, but decisions are taken by (many) sovereign states, is the core of the analysis carried out in Carraro and Siniscalco (forthcoming).

⁴ These problems are more fully analyzed in Carraro (1999a). New results are provided by Katsoulacos, Ulph, and Ulph in this book.

⁵ See the chapters by Bovenberg and Goulder and by Rauscher in this book.

⁶ For example, the Danish and Italian governments have recently implemented a policy scheme to achieve the Kyoto targets in which a modest environmental tax is linked to widespread adoption of industry specific voluntary agreements.

⁷ See the chapters by Fullerton, Hong and Metcalf and by Smulders and Vollebergh in this book.

⁸ Three good examples are the chapters by Becker and Henderson, Levinson, and Siniscalco *et al.* in this book.

⁹ The Double Dividend literature explores the implications of non-environmental benefits in addition to environmental benefits when taxes on pollution are implemented. For a recent survey on this issue, see (Bovenberg 1999).