2009

Distributional Effects of Environmental and Energy Policy: An Introduction

Don Fullerton, *University of Illinois at Urbana-Champaign*

Distributional Effects of Environmental and Energy Policy

Edited by

Don Fullerton

University of Illinois, USA

ASHGATE

Introduction

Conceptual Overview

Public economics has well-developed tools for analysing the incidence and distributional effects of all personal taxes, payroll taxes, property taxes and corporate income taxes. Some of that literature looks at distributional effects of environmental or energy taxes used to help control pollution or energy consumption. Yet most pollution policy does not involve taxation at all. Instead, it employs permits or command-and-control (CAC) regulations such as technology standards, quotas and other quantity constraints. Existing studies are mostly about effects on economic efficiency. This literature addresses questions such as: how to measure the costs of reducing pollution or energy use, how to measure benefits of that pollution abatement, what is the optimal amount of protection, and what is the most cost-effective way to achieve it.

Yet CAC environmental restrictions do impose costs, and an important question is: who bears those costs? Moreover, those restrictions provide benefits of environmental protection, and another important question is: who gets those benefits? Thus, full analysis of environmental policy could address all the same questions as in the tax incidence literature. Perhaps such analysis could also use the same tools to address distributional effects – not of taxes, but of these other policies that are used to protect the environment.

This Introduction discusses some initial literature on distributional effects of environmental and energy policy. It uses the literature on tax incidence as a starting-point, but then goes on to point out ways in which distributional effects of environmental policy are more interesting and difficult. For example, standard tax incidence literature would point out the general equilibrium implications of an excise tax: not only does it affect the relative price of the taxed commodity, and thus consumers according to how they use income (uses side), but it also impacts factors intensively used in the production of that commodity, and thus individuals according to the sources of their income (sources side). This literature is reviewed in Fullerton and Metcalf (2002).

Yet an environmental mandate can have those effects and more! To identify the major effects around which this Introduction is organized, consider a simple requirement that electric generating companies cut a particular pollutant to less than some maximum quota. This type of mandate is a common policy choice, and it has at least the following six distributional effects.

1. It raises the cost of production, so it may raise the equilibrium price of output and affect consumers according to spending on electricity (uses side).
2. It may reduce production, reduce returns in that industry, and place burdens on workers or investors (sources side).
3. A quota is likely to generate scarcity rents. Take the simple case with fixed pollution per unit output, so the only 'abatement technology' is to reduce output. Then a restriction on the quantity of pollution is essentially a restriction on output. Normally, firms *want* to restrict output, but are thwarted by anti-trust policy. Yet, in this case, environmental policy *requires* firms to restrict output. It allows firms to raise price, and so they make profits, or

rents, from the artificial scarcity of production. Just as tradable permit systems hand out valuable permits, the non-tradable quota also provides scarcity rents – to those given the restricted 'rights' to pollute.

4. If it cleans up the air, this policy provides benefits that may accrue to some individuals more than others. The 'incidence' of these costs and benefits usually refer to their distribution across groups ranked from rich to poor, but analysts and policy-makers may also be interested in the distribution of costs or benefits across groups defined by age, ethnicity and region, or between urban, rural and suburban households.
5. Regardless of a neighbourhood's air quality improvement, many individuals could be greatly affected through capitalization effects, especially through land and house prices. Suppose this pollution restriction improves air quality everywhere, but in some locations more than others. If the policy is permanent, then anybody who owns land in the most improved locations experience capital gains that could equal the present value of all future willingness to pay for cleaner air in that neighbourhood. Similar capitalization effects provide windfall gains and losses to those who own corporate stock: capital losses on stockholdings in the company that must pay more for environmental technology, and capital gains on stockholdings in companies that sell a substitute product.

   Capitalization effects are pernicious. A large capital gain may be experienced by absentee landlords, because they can charge higher rents in future years. Certain renters with cleaner air might be worse off if their rent increases by more than their willingness to pay for that improvement. Moreover, the gains may not even accrue to those who breathe the cleaner air! If households move into the cleaner area after the policy change, then they must pay more for the privilege. The entire capital gain goes to those who happen to own property at the time of the change, even if they sell it at the higher price and move out before the air improves. Similarly, new stockholders in the burdened company may be 'paying' for abatement technology in name only, with the entire present value of the burden felt by those who did own the stock at the time of enactment, even if they sell that stock before the policy is implemented.
6. Strong distributional effects are felt during the transition. If workers are laid off by the impacted firm, their burden is not just the lower wage they might have to accept at another firm. It includes the very sharp pain of disruption, retraining and months or years of unemployment between jobs. These effects are analogous to capitalization effects if the worker has a large investment in particular skills – human capital that is industry-specific. If the industry shrinks, those workers suffer a significant loss in the value of that human capital. They must also move their families, acquire new training and start back at the bottom of the firm hierarchy, with significant psychological costs.

Using these six categories in six sections, corresponding to Parts II to V of this volume, the remainder of this Introduction covers research in economics that has begun to analyse the distributional effects of environmental and energy policy.[1] Particular emphasis is given to the 21 essays published in economics journals that are reprinted in this book. To set the stage for that discussion, however, the rest of this preliminary section reviews some earlier essays and the opening essay of the volume.

---

[1] Another good review of recent literature on distributional effects of environmental policy is provided by Parry, Sigman, Walls and Williams (2006).

The classic text in the economic analysis of environmental policy is *The Theory of Environmental Policy* (1988) by Baumol and Oates, which devotes a whole chapter to distributional effects. Since this book nicely reviews the literature prior to 1988, this volume emphasizes later literature and the current state of the art. Nevertheless, Baumol's and Oates's text effectively issues two challenges to subsequent researchers. First, because research on distributional effects was neither very extensive nor well developed, the allocation of an entire chapter to it effectively challenges the field of environmental economics to deal with this topic more seriously. This collection examines how well recent researchers have risen to the challenge.

A second challenge the chapter poses is related to the idea that many effects of environmental policy are probably regressive. Consider the six categories listed above. First, it is likely to raise the price of products that intensively use fossil fuels, such as electricity and transportation. Expenditures on these products make up a high fraction of low-income budgets. Second, if abatement technologies are capital-intensive, then any mandate to abate pollution is likely to induce firms to use new capital as a substitute for polluting inputs. If this happens, capital is in more demand relative to labour, depressing the relative wage (which may also impact on low-income households). Third, pollution permits handed out to firms bestow scarcity rents on well-off individuals who own those firms. Fourth, low-income individuals may place more value on food and shelter than on incremental improvements in environmental quality. If high-income individuals get the most benefit of pollution abatement, then this effect is regressive as well. Fifth, low-income renters miss out on house-price capitalization of air-quality benefits, and well-off landlords may reap those gains. Sixth, transition effects are hard to analyse, but could well impact on the economy in ways that hurt the unemployed – those already at some disadvantage relative to the rest of us.

That is a potentially incredible list of effects that might *all* hurt the poor more than the rich. The second challenge for subsequent literature, then, is to determine whether these fears are valid, and whether anything can be done about them – other than to forego environmental improvements!

Part I of this volume opens with an essay by Don Fullerton (Chapter 1) which does not make an original research contribution in the usual sense. Rather, it is a synthesis and exposition of economic analyses to compare eight pollution control policies: taxes, subsidies, permits handed out to firms, permits auctioned by government, CAC performance standards, CAC technology mandates, and even Coase (1960) solutions where the 'property rights' to pollute might be owned by the polluter or by victims. It also shows which policies may equivalently affect each group. For example, the pollution tax and auction of permits both capture scarcity rents for the government, whereas the simple pollution quota and the handout of permits both give those rents to firms. The eight policy alternatives are compared on multiple grounds, including economic efficiency, administrative efficiency, political feasibility, enforceability and distributional effects. The essay is included here because of the simple exposition of who gains and who loses from each environmental policy. A simple diagram shows the burden on consumers, the gains to the owners of the right to pollute and the gains to those who value the environment.

Costs to Consumers

Part II of this volume deals with costs to consumers. To categorize the six distributional effects, consider the market for a polluting good (such as electricity). In Figure 1, demand reflects private marginal benefits (PMB). Yet production has private marginal costs (PMC), and the pollution externality means that social marginal costs (SMC) include marginal environmental costs (MEC).[2]

In Figure 1, the private market with no policy restriction would produce to the point where PMB=PMC, namely output Q^o. The optimal output is where SMB=SMC, at reduced output Q'. A pollution quota would effectively restrict output to Q', and we can now categorize distributional effects.

This environmental policy raises the equilibrium output price to a new 'gross' price, P^g, and it reduces consumer surplus by the trapezoid area A+D. The amount of this price increase and resulting burden depend on various considerations that must be analysed. It is relatively large, as drawn, because the elasticity of demand for this output is low compared to the elasticity of supply. If consumers can switch to good substitutes more easily, then demand is flatter, consumer burden is smaller and the loss of producer surplus is larger. Thus, the economic analysis in each case must measure both demand and supply elasticities, and the fraction of each group's income spent on this good.

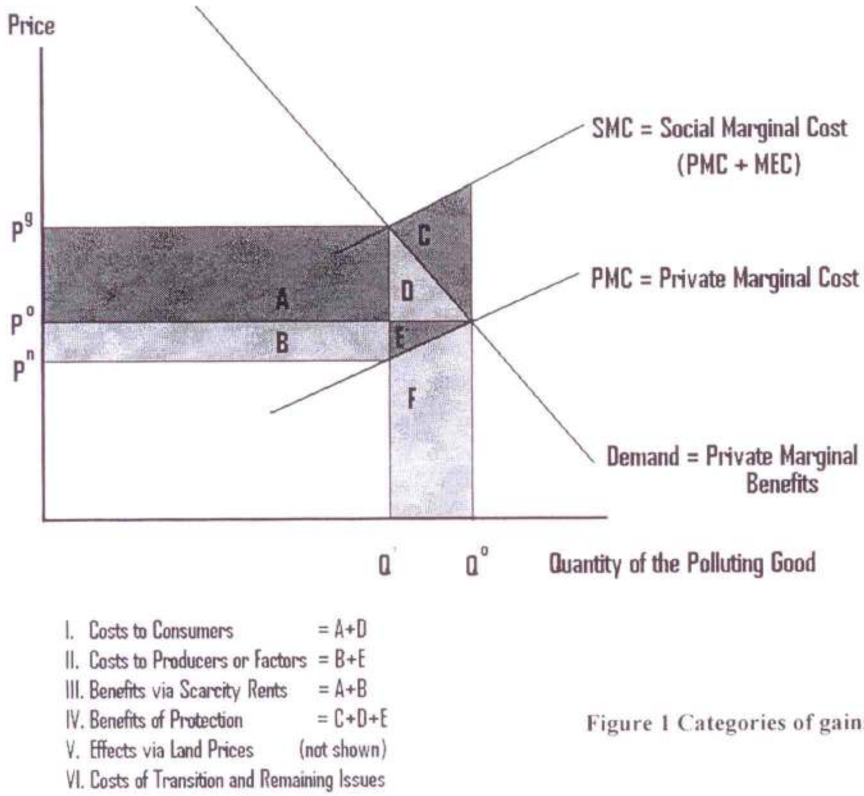

Figure 1 Categories of gains and losses

[2] For simplicity, assume that pollution per unit of electricity is fixed. Then the demand for electricity is the 'demand for pollution', and the only way to cut pollution is to cut output. The externality can be corrected by a tax on pollution, which is equivalent in this case to a tax on output. It also can be corrected by a permit system. The example in the text is a simple quota, or quantity constraint.

The Clean Air Act is likely to raise the cost of electricity, gasoline and other products that rely on fossil fuel. Estimates suggest that such spending represents a higher fraction of total spending for low-income families than for high-income families, so early studies such as Gianessi, Peskin and Wolff (1979) find that costs of the Clean Air Act in the United States are regressive.[3] In other research, Robison (1985) assumes that all industrial pollution control costs are passed forward into output prices, and he uses a disaggregated input–output model to calculate the ultimate effects on all goods purchased by 20 different income groups. He finds that burdens are very regressive, ranging from 0.76 per cent of income for the poorest group to 0.16 per cent of income for the richest group.

In Chapter 2 James Poterba looks at the gasoline tax, and he makes two points that both tend to offset that previous finding of regressivity. First, early studies rank families from the lowest annual income to the highest annual income. Yet annual income fluctuates, and it varies over the life cycle. The very young and old spend more than their annual income, because they know that annual income is temporarily low. They are not 'poor' in terms of permanent or lifetime income. Poterba points out that annual total consumption expenditure is a good proxy for permanent or lifetime income, and so he ranks families from the lowest to the highest annual consumption. Then, because those with low annual income tend to consume more of their income than those with high annual income, any commodity tax appears to be more regressive on the basis of annual income. Thus, the change to annual consumption as a proxy for permanent income makes the gasoline tax less regressive.

The second point about the gasoline tax is that the very poorest households cannot afford to own a car at all. They use public transport. Thus, Poterba finds that the gasoline tax takes up the highest percentage of 'permanent income' for those in the middle of that spectrum. Therefore, it is not strictly regressive at all. This point would not necessarily reduce the regressivity of other taxes on energy, however, if the poorest households do use a high fraction of total expenditures on heating fuel and electricity.

Another two points are raised by Margaret Walls and Jean Hanson (Chapter 3). They also compare annual and lifetime income, but do not use consumption as a proxy for lifetime income. They start with 1000 households from the 1990 National Personal Transportation Survey, which includes socioeconomic and demographic data as well as each household's vehicle make, model and year. Then, to construct lifetime income for each household, they use coefficients on household characteristics from the lifetime wage–age profiles estimated by Fullerton and Rogers (1993) using longitudinal data from the Panel Survey of Income Dynamics. Second, instead of just looking at a gasoline tax, Walls and Hanson look at emission policies. For each vehicle in the NPTS cross-section, they assign an emissions rate (using remote-sensing emissions data on 90 000 vehicles). They then calculate the effect on each household of: (1) the current system of annual registration fees based on car value; (2) basing annual fees on vehicle miles travelled (VMT) of that vehicle; (3) a fee based on the emission rate of the vehicle; or (4) on the estimated emissions of the vehicle (emissions per mile × miles).

---

[3] Even if the amount spent on electricity is higher for a rich family than for a poor family, that electricity spending as a fraction of income is found to be lower for those with high income. Thus, the policy is 'regressive', meaning that the burden as a fraction of income is lower for those with more income. The burden is 'proportional' if the ratio of burden to income is the same across all income groups, and it is 'progressive' if that burden ratio is higher for those with more income.

Interestingly, the current fees based on car value are only somewhat regressive: low-income families spend a high fraction of income on cars, but higher-income groups buy higher-valued cars. Yet those fees perversely charge *less* for the more-polluting cars (which have lower value). The attempt to fix those incentives by placing more tax on the low-value polluting cars undeniably makes the fee more regressive. The VMT fee looks a lot like the gasoline tax discussed above. The emissions fee is more regressive, because it is VMT × the emission rate, but the fee based on emissions rate is the most regressive. All such fees are less regressive when viewed from a lifetime perspective.

Instead of looking only at gasoline or vehicle taxes, Gilbert Metcalf (Chapter 4) considers a comprehensive environmental tax reform that includes a carbon tax, a gasoline tax, air pollution taxes and a virgin materials tax. Together, these would raise prices of various energy-related goods (and revenue equal to 10 per cent of current federal receipts in the United States). He then uses an input–output model to calculate both the increase in price of every industry's output and the effect of those price increases on a large sample of households from the Consumer Expenditure Survey (CEX). He shows that all of these environmental taxes are regressive when measured against annual income, to varying degrees, but each is less regressive when measured against lifetime income.

However, Metcalf then goes on to point out the importance of what is done with the revenue. If the package were revenue-neutral, the new environmental taxes could be used for a combination of: an exemption from payroll tax for the first $5000 of wages, a $150 tax credit for each exemption in personal income tax, plus an across-the-board income tax cut of 4 per cent. This tax shift is still somewhat regressive when measured by annual income, but the overall package has no effect (or is slightly progressive) when measured by lifetime income. The key point is that environmental tax reform does not need to be regressive; the revenue could be used in ways that are even more progressive than the payroll and income tax cuts assumed by Metcalf.

In Chapter 5 Sarah West studies gasoline taxes and car policies related to emissions, as do the essays reviewed above, but she makes two additional points. First, consumers have preferences over VMT, rather than gasoline *per se*, and so utility-based welfare measures are best calculated from VMT demand. Yet the price of driving a mile is endogenous. It depends on miles per gallon, which depends on the choice of vehicle, which depends on the price of gasoline and on all of the household's unobserved characteristics. Since the price of a mile is endogenous, a regression of VMT demand on VMT price would yield biased coefficients. She corrects for this bias by first estimating discrete demand for vehicle type and then using those results in the estimation of continuous demand for VMT. This correction is important, and most good subsequent studies of car and gasoline demand have undertaken similar corrections.

Her second major point is that groups have different price responsiveness. She uses total consumption to classify households from poor to rich (as a proxy for permanent income), and she estimates VMT demand for each decile separately. She finds that poorer groups are more price-responsive, which reduces their gas tax burden. In Figure 1 above, their demand would be flatter, and so the same increase in price (from P^o to P^g) would reduce quantity more (from

Q^o to Q'). It would thus shrink their loss in consumer surplus (area A+D). This effect reduces the regressivity of the gasoline tax.[4]

The final essay included in Part II is by Sarah West and Roberton Williams (Chapter 6). In their words, their 'study makes two main contributions' (p. 118).[5] First, they use an estimated demand system to calculate four different measures of 'burden' for each group. The simplest procedure used in the early literature assumes no price responses, but West and Williams also calculate a consumer surplus measure assuming all groups have the same price response, a consumer surplus measure using each group's own price response, and an additional measure based on the equivalent variation for each group. The first of those makes the gasoline tax look most regressive. As in West's other essay (Chapter 5), the use of each group's own response makes the gasoline tax look least regressive. West's and Williams's second main contribution is to calculate incidence for three different assumptions about use of the revenue. The gasoline tax is most regressive with no return of revenue, it is less regressive when revenue is used to reduce wage taxes, and the whole reform becomes progressive when revenue is used to provide the same lump-sum rebate to each household. This last result highlights the trade-off between equity and efficiency, since the uniform lump-sum rebate cannot reduce income tax distortions by cutting taxes on work effort.

Costs to Producers or Factors

Energy or environmental policy may also impose burdens on producers or on factors of production. Figure 1 (p. xiv) shows a simple partial equilibrium model, where the loss in producer surplus (area B+E) is relatively small because the supply curve (PMC) is relatively elastic. These losses could be larger if, instead, production involves industry-specific resources in relatively fixed supply, such as a specific type of energy, land with specific characteristics, or labour with industry-specific skills. If so, then the cut-back in production burdens the owners of those limited resources.

A general equilibrium model could be used to solve for the new economy-wide wage, rate of return or land rents, and a more sophisticated dynamic general equilibrium model could be used to solve for short-run effects, capital deepening and the transition to a new balanced growth path with a new labour–capital ratio.

The early development of this literature is exemplified by the dynamic growth model of A. John and R. Pecchenio (Chapter 7). In this model, production uses labour, physical capital and natural environmental capital. Each agent's earnings when young are allocated between savings for consumption when old, or for maintenance of the environment. That choice takes

[4] Many of the poorest households don't own cars or buy gasoline, so the gasoline tax is somewhat progressive over the first few deciles and then regressive over remaining deciles. The fact that the price elasticity falls with income means that the gasoline tax is even more progressive over the first few deciles and less regressive beyond that. West also calculates the incidence of a subsidy to newer cars; it may encourage the purchase of newer cars with lower emission rates, but it is a decidedly regressive policy.

[5] Like the other essays discussed above, it really makes more than two contributions. Unfortunately, however, space constraints here preclude more than about two points from each essay included in this volume.

into account that environmental maintenance can increase welfare when old, but it does not take into account the welfare of unborn generations. Thus the framework is useful for studying a particular kind of distributional effect – between generations. As in other natural resource models, this economy can have multiple equilibria: one with low environmental maintenance that leads to low production and low investment, and the other with high physical capital and good environmental quality. This insight also helps explain some observed distributional differences between rich and poor countries – even poor countries that start with abundant resources. The essay also describes alternative transition paths: one with growing capital and degrading environment, one with both capital stocks shrinking, and one with both growing. It also points to the importance of environmental accounting, since rising income does not necessarily mean rising welfare for future generations.

A different kind of general equilibrium model is discussed by Don Fullerton and Garth Heutel (Chapter 8). It is not a growth model, since labour and capital are both in fixed supply, but it can be used to solve analytically for the effect of an energy tax on multiple output prices and factor prices – including the wage for labour and the return to capital. The 'clean' sector uses only labour and capital, but the 'dirty' sector uses labour, capital and pollution. With three inputs, any two can be complements or substitutes. First, the 'substitution effect' places a smaller burden on whichever factor is a better substitute for pollution (and a larger burden on the other one). Second, because the pollution tax raises output price and reduces production, the 'output effect' is likely to place a higher burden on whichever factor is intensively used in the dirty sector.[6]

Fullerton and Heutel then look at special cases. Even if both factors are equal substitutes for pollution, the intensively-used one does not always bear a greater burden. If the dirty sector is capital-intensive, for example, the output effect would tend to place more burden on capital, depending on consumers' ability to substitute between the two outputs. But if that effect is relatively small, it can be more than offset by the fact that the dirty sector is trying to substitute out of pollution and into *both* capital and labour at its current capital–labour ratio, which means *less* burden on capital. Finally, these authors employ stylized facts and plausible parameter values to conclude that 'the impact of factor intensities over the plausible range is less important than the impact of the elasticities of substitution between pollution and capital or labor' (p. 177). In other words, to know who bears the burden of energy policy, it is important to estimate cross-price elasticities.

In a 2007 working paper, Fullerton and Heutel note that most environmental policies do not use taxes. Instead, regulators have employed CAC restrictions on the quantity of pollution (a 'quota'), on pollution per unit output (a 'performance standard'), or on pollution per unit of some input (a 'technology mandate'). They find the same effects as before, but identify other new effects as well. The restriction on the ratio of pollution to output can be achieved both by reducing pollution in the numerator *and* increasing output in the denominator. Thus, it involves an implicit 'output subsidy'. Under plausible conditions, this effect can *help* any factor that is intensively used in the polluting sector.

[6] In this model, environmental quality is separable in utility. In a more complicated model, the increase in environmental quality itself could affect the relative demands for goods and thus returns to factors.

In other words, actual policies can be tricky. With multiple offsetting effects on the wage rate and return to capital, we cannot just assume that a restriction on the polluting sector will injure whatever factor is intensively employed there.

Benefits via Scarcity Rents

When the quantity of the polluting good is restricted in Figure 1, the restriction makes the good scarce and gives rise to scarcity rents (area A+B). If the policy is a tax on pollution or the auction of permits, then the government captures those scarcity rents as revenue. If the policy is a handout of permits or a quantity restriction (quota), then area A+B becomes profits to the firms that are allowed to produce and sell that newly restricted quantity. That simple theory may be obvious in the case of Figure 1, where pollution is a fixed ratio to output, because then a restriction on pollution also restricts the quantity of output. But what if firms can abate pollution per unit of output? What if the policy requires a particular technology, and entry is permitted?

Michael Maloney and Robert McCormick (Chapter 9) show how scarcity rents can still be generated in these circumstances, and they provide empirical evidence for two different regulations, using data on stock market returns around the time the new regulation is imposed. First, in 1974, the US Occupational Safety and Health Administration imposed new cotton-dust technology standards uniformly on all textile firms.[7] Looking at a portfolio of 14 textile stocks, they find a significantly positive abnormal return around the time this rule is imposed. This result is not sensitive to various alterations of the model and time period, and it is not explained by other events at the time.

In addition, many rules do effectively restrict entry by imposing stricter regulation on new firms only, while 'grandfathering' existing firms. Maloney and McCormick also look at the 1973 decision of the US Supreme Court in favour of environmental groups that sued the EPA to 'prevent significant deterioration' of air quality in areas already in compliance with National Ambient Air Quality Standards. Because this decision could not be fully anticipated, it represents a good 'event' to study. Only new entrants are forced to meet stricter standards, especially those who emit sulphur oxides and particulates. These emissions are concentrated in non-ferrous ore smelting, so they look at stock prices of existing copper, lead and zinc smelters. Again, they find significant positive abnormal returns to existing firms in those industries.

One might think that producers would abhor costly new regulations, in a political battle between polluters and environmentalists, but this evidence suggests that 'the interests of environmentalists and producers may coincide against the welfare of consumers' (pp. 185–86). The implications are important not only for the political economy of enacting environmental legislation, but also for the distributional impact: environmental policies impose abatement

[7] If marginal and average costs were perfectly flat and identical for all firms, and if this regulation shifted costs up by the same amount for all firms, then none would make profits. But if a fixed number of competitive firms have U-shaped average cost curves, then a new technology standard may increase marginal costs more than average costs. If so, the new intersection of demand and marginal cost determines a price that is above average cost, generating profits.

costs that must be borne by producers and consumers, but can also provide significant benefits to others by generating profits.

The United States is now contemplating a policy to limit carbon emissions that contribute to global warming, and such a policy might have huge effects both because fossil fuel is such a large input to production *and* because the policy might require large reductions. In Chapter 10 Terry Dinan and Lim Rogers find that restricting emissions by just 15 per cent, relative to business as usual, would raise prices by 2.8 per cent. If this policy were a carbon tax, it might raise $128 billion (in 1998 levels and dollars). More probably, however, US policy would hand out tradable permits and $128 billion of private profits for firms. Thus, the authors find that 'the magnitude of the wealth that would be redistributed … could substantially exceed the actual cost to the economy' (p. 212).[8]

Dinan and Rogers use results from Metcalf's input–output model on the carbon content and price increase for each commodity (see Chapter 4), and they use a large sample of 57 247 households from the Current Population Survey matched with tax return data from the Statistics of Income and Consumption data from the CEX. They also account for a few intricacies: first, the permit policy would exacerbate deadweight losses from taxes that have their own distributional effect; second, the corporate tax would capture for government some of the profits; third, the policy decision about the use of that revenue would have its own distributional effects; fourth, the higher output prices would trigger increases in indexed transfer programmes like Social Security, with further distributional effects. With all of these intricacies, the predominant effects are still: (1) low-income households spend more of their income on carbon-intensive products; and (2) high-income households own the corporations that receive profits. Thus, the policy is overall highly regressive unless government captures a higher fraction of the scarcity rents *and* uses that money to provide an equal lump-sum amount to every individual.

Ian Parry (Chapter 11) addresses some of the same questions, but uses a more stylized analytical model with less detailed calculations but with explicit formulas that show the impacts of underlying parameters. He also looks at other pollutants (SO_2 and NO_X) and other policies (performance standards, technology mandates and taxes on dirty inputs). He finds that grandfathered permits benefit stockholders and thus can provide gains to high-income groups while imposing large costs on the poor. This effect is diminished with more substantial requirements for abatement. The burden on low-income groups can be reduced by the other policies that do not provide windfall profits to stockholders. When abatement costs differ between sources, a permit system can minimize the overall costs of abatement, but that gain in economic efficiency can be offset by the social costs of adverse redistribution if the social welfare function exhibits aversion to income inequality. In other words, social welfare might be raised more by inefficient CAC mandates than by grandfathered permits. And the auction of permits achieves efficiency without that handout of profits to wealthy stockholders.

A rather contrary view is expressed in Chapter 12 by Louis Kaplow, who suggests that evaluation of the economic efficiency of such a reform need not account for adverse distributional effects at all! If a gasoline tax or other pollution policy imposes costs on low-

[8] Theory suggests that US firms could profit from the distribution of these carbon permits, but this theory is confirmed by evidence for the European Union's Emissions Trading System. Sijm, Neuhoff and Chen (2006) find that 60–100 per cent of the cost of CO_2 permits is passed through to consumers in Germany and the Netherlands, even though power companies receive permits for free. Firms thus realize substantial windfall profits.

income groups and benefits to high-income groups, those redistributive effects could be offset by adjustments to the income tax. Moreover, any policy's adverse distributional effects should not be attributed to the policy but, rather, to the failure to make those income tax adjustments. The point is that we need not choose the less efficient environmental policy in order to avoid adverse distributional effects, since we could instead offset those effects through income tax adjustments. His argument is more complicated and subtle than can be stated in this short Introduction, which is a good reason to include the whole essay in this volume.[9] The interesting conceptual point is not that environmental policy can proceed regardless of measured effects on distribution. Indeed, measures of distributional effects provided by the various essays in this book are important in order to know *how* to adjust income tax in a way that would neutralize these distributional effects.

Because quotas or grandfathering of permits provides benefits to firms as well as to environmentalists, it can create a powerful coalition that greatly increases the political feasibility of environmental protection. Lans Bovenberg, Lawrence Goulder and Derek Gurney (Chapter 13) investigate exactly what fraction of permits or rents must be allocated to firms to cover their losses, while other permits are sold at auction to achieve greater efficiency by cutting distortionary taxes. They build analytical and numerical models with perfect competition, constant returns to scale, a clean good, an intermediate good, and a final good produced in a polluting process. All three goods use labour and capital. If those inputs were perfectly mobile, then each industry would earn zero profits both before and after a pollution tax or auction of permits, so the simplest case implies that no permits need to be grandfathered to firms. Yet Bovenberg *et al.* recognize adjustment costs in the reallocation of capital, so firms would indeed make losses upon the imposition of a sector-specific policy. For little abatement, they find that only about a quarter of permits must be handed out, but higher levels of required abatement increase that fraction – and the loss in efficiency from not cutting other taxes.

Benefits of Protection

A policy to abate pollution also provides benefits to those who breathe the air, those who drink the water and those who enjoy recreation. In Figure 1, these gains are represented by area C+D+E, the sum of 'marginal environmental damages' over the range that pollution is reduced (from Q^o to Q'). Who are these individuals, and what socioeconomic groups receive most of these benefits? These questions are related to who bears the cost of pollution (except that a proposal may not abate pollution proportionately everywhere). A key question is whether polluters choose to locate disproportionately in poor or minority areas. This is the question of 'environmental justice.'

The essay by Nancy Brooks and Rajiv Sethi (Chapter 14) is representative of early attempts to address these questions. Brooks and Sethi employ much data from the 1988–1992 Toxic Release Inventory (TRI) in the United States, plus 1990 census data on race, ethnicity, poverty status and educational attainment at the zip code level. They improve upon prior essays by weighting different air emissions according to toxicity and calculating, for each zip code, an exposure based on the distance to various pollution sources around it. They regress this

[9] In particular, he assumes that leisure is separable in utility, whereas many other essays assume instead that the environment is separable in utility.

exposure on census variables and other controls and find that exposure is significantly and positively related to: the proportion of blacks in the community, the proportion who are renters, the percentage of poor, lower voter turn-out, and lower educational attainment. Most of the essay is careful to discuss the 'relationship' between exposure and these socioeconomic variables, but some of it lapses into causal interpretations. The main problem is the endogeneity of all these variables: if high pollution reduces local land values and housing rents, and if low-income households have more need for basic necessities than for the 'purchase' of clean air, then low rents may bring them into the area – reverse causality. If so, then estimated coefficients are biased, and pollution does *not* impose disproportionate burdens on poor and minority households.

The possibility of simultaneous location decisions by households and firms was raised as early as 1994 by Vicki Been. This problem is pernicious, however, and pervades the literature. Few have tried to model both decisions simultaneously. For example, Diane Hite (Chapter 15) looks at endogenous location choices of households, given fixed locations for environmental harms. She estimates a 'random utility model' of location choices using 2889 house sales with data on house characteristics, neighbourhood characteristics and distance to any of the four landfill sites around Columbus Ohio. With full information and no location constraints such as discrimination, then no household would envy another in the sense of preferring the other's consumption bundle. Using the model, she can calculate the probability that a household in one area with estimated preferences would really prefer to live in a different area. If so, it could indicate discrimination. She finds some evidence for environmental discrimination against African-American households, but not against poor households. Note that this potential discrimination would be discrimination in housing markets. Since polluter locations are fixed, she does not look at discrimination in location decisions of firms.[10]

A further step towards dealing with the simultaneous location decisions by both firms and households is taken by Wayne Gray and Ronald Shadbegian in Chapter 16. They look at many determinants of air and water pollution and of enforcement actions at 409 pulp and paper mills from 1985 to 1997, including local demographic variables. They recognize potential for reverse causation, however, since poor households could move into dirty neighbourhoods for cheaper housing, and those with small children or elderly people, who are sensitive to pollution, could move out. Thus, demographics near the plant are endogenous, and OLS regressions are biased. They do not model household location decisions directly along with polluter location decisions, because the sample of plants is quite old. Instead, they run a regression of those endogenous local characteristics on a set of instruments – namely, the demographic characteristics of people living 50–100 miles away from the polluting plant. The idea is that these 'spatially lagged' variables are highly correlated with local characteristics, but not influenced by effects of pollution from that plant, since pollution effects decline with distance. Using predicted local characteristics in place of actual local characteristics, they find that plants in poor neighbourhoods emit more pollution, and those near children or the elderly emit less, but, surprisingly, they find that plants in non-white neighborhoods also emit less pollution.

[10] In a 2002 working essay, Ann Wolverton looks directly at plant location decisions and the community characteristics at the time the plant was originally sited. She finds that the polluting plants in her sample did not locate disproportionately in minority neighborhoods.

Most of this Introduction is concerned with distributional effects across income groups, although this section has touched on effects across ethnic groups. However, effects of environmental policy could be measured across groups defined by age, health status, region or other breakdown. Also, most of the studies in Part V employ various 'revealed preference' data on willingness to pay (WTP) for a cleaner environment, such as through house prices. In contrast, Anna Alberini, Maureen Cropper, Alan Krupnick and Nathalie Simon (Chapter 17) use surveys of 'stated preferences' to look at WTP by different groups defined by age and health status.

When the US Environmental Protection Agency (1999) looks at all costs and benefits of the Clean Air Act, they find the huge majority of benefits in the form of mortality reductions. Who benefits from these mortality reductions? Theoretical predictions are ambiguous. Older or less healthy individuals have a higher baseline mortality risk, and thus might be willing to pay more for a reduction in the risk of dying this year. If so, environmental policy benefits the elderly and infirm. On the other hand, they may have fewer years to live, and for that reason be willing to pay less for a reduction in the risk of dying this year. Following established contingent valuation techniques, Alberini *et al.* survey 930 Canadians and 1200 Americans.[11] They find an overall value of a statistical life (VSL) between $1.5 and $4.8 million, somewhat less than the $6 million figure used by the EPA. Although no statistically significant age effect is found in the United States, the WTP falls significantly after age 70 in Canada. The WTP rises with income in both samples, but significantly only in the United States. The value of risk reductions is significantly higher in both samples for those with a family history of chronic heart or lung disease and for those recently admitted to a hospital for a heart or lung condition.

Trudy Cameron and Ian McConnaha (Chapter 18) do not provide direct evidence on distributional effects of environmental policy, but they do shed light on whether polluters locate in certain types of neighbourhood, whether people 'come to the nuisance', or both. They look simply at migrations between the four census measurements over three decades (1970–2000), in response to environmental hazards and subsequent clean-ups. The units of observation are census tracts within a 12-mile radius around each of four contaminated Superfund sites. For the vicinity around each site, they estimate changes in the distance profile over time for the concentration of each of 22 household characteristics (using 88 different regressions). For ten of the 22 characteristics, they find statistically significant changes in its relative concentration near the site over time (as these sites are identified and then cleaned up). In the first decade after the contamination is announced, they find declines in the prevalence of 'children under six' and 'married couples with children', and increases in seniors, married couples without children, female-headed households without children and non-family households. In many cases, those migrations are reversed in the decade after a clean-up is complete. Results on non-whites differ across their four sites.

The implication here is not just that families with children might well be burdened by pollution, but that they move away! Other, less sensitive groups take their place. This

[11] The protocol includes much information on changes to risk, and yes–no dichotomous choice questions about whether the respondent would be willing to purchase that reduction in risk for a particular price (chosen randomly from one of four predetermined values). Additional questions relate to income and health status, followed by debriefing questions to check the respondent's comprehension.

evidence makes it very difficult, in the next generation of literature, for researchers to take neighbourhood characteristics as exogenous – as done by some earlier researchers. Other evidence reviewed above makes it equally difficult to take pollution levels as exogenous. The simultaneity of household and polluter location choices continues to be one of the greatest challenges to economic research in this area.

Effects via Land Prices

The gains and losses each period that are depicted in Figure 1 can be capitalized into asset prices. Part IV of the volume, as discussed above, focused on how the annual flow of 'scarcity rents' (area A+B) is capitalized into corporate stock prices, and Part VII discusses how the 'benefits from environmental protection' (area C+D+E) are capitalized into land prices. If a policy provides cleaner air to a particular neighbourhood, the entire present value of those gains can be captured by whoever owns a house site at the time of the change.[12] Those individuals who gain may not be the same as those who breathe the cleaner air. Similarly, if certain households migrate into an area near a contaminated Superfund site to take advantage of cheaper housing, then the clean-up of that site does not compensate those who suffered the losses from the environmental hazard.

Since at least Ridker and Henning (1967), economists have estimated house price as a hedonic function of house and neighbourhood characteristics such as air quality, water quality or distance from a toxic waste site. The coefficient on such a variable indicates the market's willingness to pay for improvement in that environmental measure.[13] This method will not easily reveal the distributional effects of all pollution, or all abatement policies, but it can be used to calculate the distribution of gains from a marginal policy to abate. Ted Gayer (Chapter 19) uses 6562 house sales and GIS data to calculate distance to each Superfund site around Grand Rapids, Michigan. However, the environmental risk itself may be determined in part by house prices, if polluters are more likely to locate near inexpensive homes. If so, the usual OLS regression of house price on house and neighbourhood characteristics and this environmental risk yields biased coefficients. Gayer finds that this variable is indeed endogenous, and he corrects for it using a first-stage regression of that risk on exogenous instrumental variables. Results indicate that welfare gains of risk reduction would be greater for neighbourhoods with high income and education, and lower for neighbourhoods with more non-whites.

This correction for endogeneity is an improvement. Nevertheless, Gayer's exogenous instruments still include the neighbourhood's socioeconomic variables as well as measures of potential for collective action. Firm location or pollution decisions can help affect environmental risks and house prices simultaneously in his model, but household characteristics are exogenous. Thus, this research does not yet solve the chicken–and-egg problem regarding whether polluting firms locate in low-income and minority neighbourhoods, or poor families arrive later to take advantage of low house prices.

---

[12] That statement is strictly true only with inelastic supply of land. The price change is moderated if supply is elastic, such as by the conversion of more fringe land into residential use.

[13] An excellent recent example of hedonic house price estimation is Chay and Greenstone (2005). Their estimates could be used to study distributional effects, but they focus mostly on aggregate estimates correcting for omitted variable bias and self-selection issues.

Using data from 1989–91 in Southern California, Holger Sieg, Kerry Smith, Spencer Banzhaf and Randall Walsh (Chapter 20) estimate the parameters of a structural model that can be used to calculate the welfare effects of *large* air-quality improvements, such as those from 1990 to 1995 that reduced ozone from 3 per cent to 33 per cent across different US neighbourhoods. They incorporate how preference heterogeneity leads some households to respond to changes in local amenities by moving, which induces changes in house prices, which might induce further moves until a new equilibrium is attained. Their essay shows that the general equilibrium calculation of value accounting for these house-price changes is quite different from the partial equilibrium value based on fixed house prices. In the results for particular locations, the two measures differ much more than on average and may have different signs. Even when a poor location experiences some improvement, house price increases can offset that benefit. In one location where ozone fell by 24 per cent, house prices rose nearly 11 per cent. Thus, poor families may lose, while landlords gain.

While local or regional pollutants may be capitalized into residential land prices, global effects can be capitalized into other land prices. Mendelsohn, Nordhaus and Shaw (1994) regress agricultural land prices on soil attributes and other local characteristics including temperature, precipitation and other climate variables. The use of a cross-section implies that all farmers have already adapted to their climate. This Ricardian method can be used to calculate the long-run gain or loss to each location from climate change. A few such studies have been undertaken for developing countries.

Robert Mendelsohn, Ariel Dinar and Larry Williams (Chapter 21) use such results to calibrate response functions for each sector of each country. They then employ three different climate models to predict temperature and precipitation for a grid of points on the globe in the year 2100 and calculate the gain or loss to each country. The authors find that poor countries suffer most of the damages from global warming. The reason is not that those countries will experience more dramatic climate change than other countries; indeed, results are similar when merely assuming that all experience the same changes. Rather, poor countries suffer the most damage because they are already in warmer locations. Poor countries near the equator become even warmer and less productive, while richer countries in cool climates become warmer and more productive.

This essay also offers a good example of the multiple ways of defining distributional effects of environmental policy – across different countries, as well as within a country between groups defined by income, age or ethnicity.

Conclusion: Costs of Transition and Remaining Issues

This Introduction has reviewed studies of the effects of environmental policy on consumers and on producers, through scarcity rents and benefits of protection. Other effects of environmental policy, such as adjustment costs and other transition costs, are not as well studied in available literature, however. In Figure 1, area F represents the value of inputs no longer employed in this industry. They are often assumed to be re-employed elsewhere, with no loss. Yet a change in environmental policy can be very disruptive, especially for a local economy highly dependent on the resource just protected. Logging or mining is often a predominant occupation in a town that can be virtually annihilated by environmental protection. Individuals in such areas may acquire a great deal of industry-specific human capital, the value of which is lost by the shrinking of that industry. This human capitalization effect can imply a much larger percentage loss for individuals than other asset price capitalization effects of environmental policy discussed above.

The first section of this Introduction described two challenges of Baumol and Oates (1988), so we now turn to judge progress in subsequent literature. First, the authors challenge economists to deal more seriously with distributional effects of environmental policy. While the prior literature does emphasize effects on economic efficiency, the collection of essays in this volume provides ample evidence that economists are indeed beginning to study distributional effects. Yet much remains to be done.

The second challenge of Baumol and Oates (1988) is to determine whether energy or environmental policy is really as regressive as it appears, and, if so, what can be done about it. Essays in this volume show that environmental protection does probably raise the price of goods such as electricity and transport that constitute high fractions of low-income budgets. In addition, pollution permits handed out to firms bestow scarcity rents on the well-off individuals who own those firms. Yet some of the essays in this volume show how rebates to low-income households can offset those regressive effects and allow for environmental protection without adverse distributional consequences. This point makes it important to use emissions taxes, or the auction of permits, to raise enough revenue to cover the cost of those rebates.

Other essays in this volume estimate whether high-income individuals get more benefits from environmental protection, because of higher willingness to pay. Results are mixed. Certainly high-income families have more ability to pay, and thus may have higher demand for recreation and other environmental amenities, but the actual valuation by different groups depends on what amenity is being valued. Thus, environmental policies can be designed to provide sufficient protection to low-income neighbourhoods. Some of the most pernicious effects of environmental policy, however, are the capitalization effects that provide windfall gains and losses. Those who own land or corporate stock at the time of environmental damage suffer a capital loss, and they may sell that asset before the abatement policy is implemented. It then provides gains to others who did not suffer the loss. Capitalization effects also apply to human capital, with even greater proportional gains and losses to individuals. These effects are also a challenge to the economics profession.

References

Baumol, William J. and Wallace E. Oates (1988), *The Theory of Environmental Policy* (2nd edn), New York: Cambridge University Press.

Been, Vicki (1994), 'Locally Undesirable Land Uses in Minority Neighborhoods: Disproportionate Siting or Market Dynamics?', *Yale Law Journal*, **103**, pp. 1383–422.

Chay, Kenneth and Greenstone, Michael (2005), 'Does Air Quality Matter? Evidence from the Housing Market', *Journal of Political Economy*, **113**(2), April, pp. 376–424.

Coase, Ronald (1960), 'The Problem of Social Cost', *Journal of Law and Economics*, **3**, pp. 1–44.

Fullerton, Don and Heutel, Garth (2007), 'The General Equilibrium Incidence of Environmental Mandates', NBER Working Paper No. 13645, Cambridge, MA: NBER.

Fullerton, Don and Metcalf, Gilbert E. (2002), 'Tax Incidence', in Alan Auerbach and Martin Feldstein (eds), *Handbook of Public Economics*, Volume 4, Amsterdam: North Holland.

Fullerton, Don and Rogers, Diane Lim (1993), *Who Bears the Lifetime Tax Burden?*, Washington DC: The Brookings Institution.

Gianessi, Leonard P., Peskin, Henry M. and Wolff, Edward (1979), 'The Distributional Effects of Uniform Air Pollution Policy in the United States', *Quarterly Journal of Economics*, **93**, May, pp. 281–301.

Mendelsohn, Robert, Nordhaus, William D and Shaw, Daigee (1994), 'Measuring the Impact of Global Warming on Agriculture', *American Economic Review*, **84**(4), pp. 753–71.

Parry, Ian, Sigman, Hilary, Walls, Margaret and Williams, Roberton (2006), 'The Incidence of Pollution Control Policies', in H. Folmer and T. Tietenberg (eds), *International Yearbook of Environmental and Resource Economics 2006/2007*, Cheltenham: Edward Elgar Publishers.

Ridker, Ronald G. and Henning, John A. (1967), 'The Determinants of Residential Property Values with Special Reference to Air Pollution', *Review of Economics and Statistics*, **49**, May, pp. 246–57.

Robison, H. David (1985), 'Who Pays for Industrial Pollution Abatement?', *Review of Economics and Statistics*, **67**, November, pp. 702–706.

Sijm, Jos, Neuhoff, Karsten and Chen, Yihsu (2006), 'CO2 Cost Pass-Through and Windfall Profits in the Power Sector', *Climate Policy*, **6**(1), pp. 49–72.

Wolverton, Ann (2002), 'Race Does Not Matter: An Examination of a Polluting Plant's Location Decision', mimeo, US Environmental Protection Agency, National Center for Environmental Economics, Washington, DC.

US Environmental Protection Agency (1999), 'The Benefits and Costs of the Clean Air Act, 1990–2010', Report to the US Congress, Washington, DC: EPA.