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Six Distributional Effects of Environmental Policy

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Abstract

While prior literature has identified various effects of environmental policy, this note uses the example of a proposed carbon permit system to illustrate and discuss six different types of distributional effects: (1) higher prices of carbon-intensive products, (2) changes in relative returns to factors like labor, capital, and resources, (3) allocation of scarcity rents from a restricted number of permits, (4) distribution of the benefits from improvements in environmental quality, (5) temporary effects during the transition, and (6) capitalization of all those effects into prices of land, corporate stock, or house values. The note also discusses whether all six effects could be regressive, that is, whether carbon policy could place disproportionate burden on the poor.

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Existing literature in environmental economics emphasizes efficiency effects of pollution controls. It shows how to measure the costs of reducing pollution or energy use and how to measure the benefits. Overall benefits are balanced against overall costs to determine the optimal amount of abatement and to determine the most cost-effective way to achieve it. Fewer studies address the question of who bears those costs or receives those benefits, even though any individual's net gain or loss as a fraction of income may greatly exceed the economy-wide gain or loss as a fraction of income.

A huge literature in public economics studies the distributional effects of taxes, but for several reasons, the study of the distributional effects of environmental policy can be much more difficult and interesting. First of all, most pollution policies are not taxes at all, but instead employ permits or command and control (CAC) regulations such as technology standards, quotas, and other quantity constraints. Second, the effects of environmental policy are much more varied, intricate, and indirect. Standard methods of tax incidence find effects on product prices and on returns to labor and capital, but energy or environmental policy can have six separately identifiable effects. Very different kinds of models and data are necessary to analyze each of these effects, and so no single study could possibly incorporate all such effects simultaneously.

These six effects are identified in the literature reviewed by Fullerton (2009), but that literature touches on many different policies and methods of estimation.[1] This short note cannot review all that literature. Instead, for coherency, it illustrates all six effects using a single comprehensive example, namely, a carbon permit system such the cap-and-trade legislation that passed the U.S. House of Representatives in 2009 (which then stalled in the Senate). No other paper discusses all effects in the context of one policy, so the contribution of this note is to illustrate how one climate policy can have all six effects simultaneously. For any given person, the six effects may augment or offset each other. In this particular case, many or all effects may all be regressive (net burden as a fraction of income that is higher for the poor than for the rich).[2] An implication is that a reform package can include features to offset losses to low-income families.

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[1] The tax incidence literature is reviewed by Fullerton and Metcalf (2002). Some of the distributional effects of environmental policy are discussed in a chapter of the classic text by Baumol and Oates (1988). Another recent review of literature on these distributional effects is in Parry, et al (2006).

[2] A policy is regressive if the burden to income ratio is lower for those with more income. It is proportional if burden/income is the same for all groups, and it is progressive if that ratio is higher for those with more income. Even if the amount spent on electricity rises with income, the fraction of income spent on that good falls with income. Thus, any increase in the price of electricity is likely regressive.

The rest of this section summarizes the six effects of climate policy and how each might be regressive. The following six sections discuss each effect in more detail.

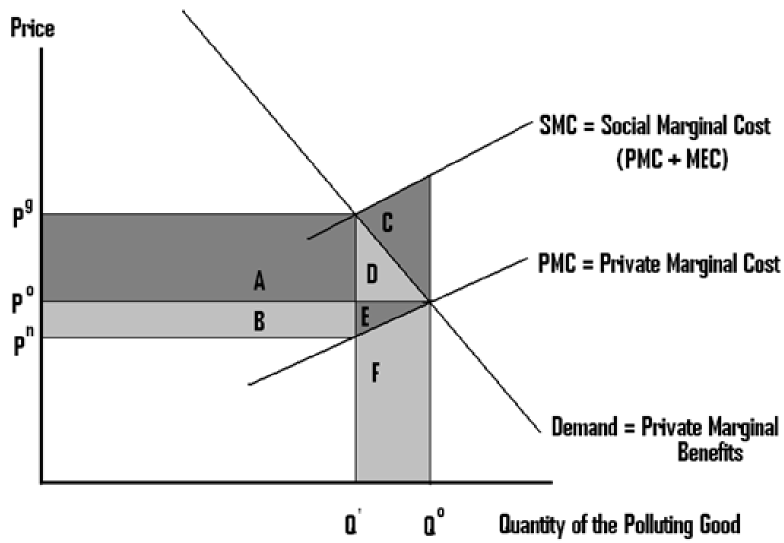
First, a carbon permit policy is likely to raise the price of products that intensively use fossil fuels, such as electricity, heating fuel, and gasoline. Low-income families use a relatively high fraction of their income to buy these goods, so they have high burdens on the "uses side" of income. Second, if abatement technologies are capital-intensive, then any mandate to abate pollution likely induces firms to use new capital as a substitute for polluting inputs. If so, then capital demand rises relative to labor, depressing the relative wage. Low-income families receive a relatively high fraction of income from wages, so they may have high burdens on the "sources side" of income. Third, pollution permits handed out to firms bestow scarcity rents on well-off individuals who own those firms.

Fourth, climate policy provides benefits if it helps improve local air quality, reduce global warming, and avoid sea-level rise. Low-income individuals may place more value on food and shelter than on incremental improvements in air quality, while high-income households may own the ocean-front property saved by climate policy. If so, then this effect is regressive as well. Fifth, the transition to cap-and-trade will impact households differentially. Unemployment may be experienced by loggers and coal miners, while premiums go to skilled workers in renewables and other energy-efficient technologies. Sixth, each of those five effects might be capitalized into the price of an asset such as a house or corporate stock. If so, then the owner gets not just those effects on income flows, but the present value of expected future flows. Capitalization effects shift around the burden. If climate policy will reduce sea level rise and save certain oceanfront homes, for example, then the benefit may be experienced not by the person who buys the house later and enjoys the oceanfront, but by the person who owns the house at the time of enactment. If climate policy also raises ambient air quality, benefits might not accrue to low-income renters who have to pay higher rents, but to well-off landlords who own the house. Climate policy may also raise the market value of high-tech energy stocks and reduce those of traditional fossil fuel companies.

These effects are best analyzed in a general equilibrium model that accounts for all markets simultaneously, including changes in production that affect the relative price of each input, each output, and each asset. A comprehensive model of this type is called a computational general equilibrium (CGE) model or an integrated assessment model

(IAM).[3] For expositional purposes, however, all six effects can be explained in a partial equilibrium diagram of a single market (as in Fullerton, 2009). In the case of climate policy, firms could reduce carbon dioxide (CO_2) emissions per unit of output (e.g., per kwh of electricity). The simplest way to show all effects in one diagram, however, is temporarily to assume fixed emissions per unit. Then the supply and demand for carbon is essentially the same as the supply and demand for the output.

Figure 1: Categories of Gains and Losses



In Figure 1, using this example, the demand curve reflects the private marginal benefit (PMB) of electricity. The supply curve reflects private marginal cost (PMC). Yet production causes an externality, because the cost of pollution is borne by others, not by the firm. Then the total cost of each unit is the social marginal cost (SMC), including both private marginal cost (PMC) and marginal external cost (MEC). In this diagram, the unfettered private market produces to the point where PMB=PMC, namely output Q^o. The optimal output is where SMB=SMC, at reduced output Q'. An ideal policy would somehow restrict output to Q'. In the simple case with fixed emissions per unit output, a set number of CO_2 permits could restrict sales to Q'. In effect, supply is vertical at Q', so the new intersection of supply and demand is at equilibrium gross price P^g. After firms pay for permits, the new net price is P^n. The price of a permit is the difference ($P^g – P^n$). If the industry is competitive, then pure profits are zero: net sales revenue is just enough to pay for all other inputs to production, such as labor, capital, fuel, and materials.

[3] Examples of such models are described in Nordhaus (2008), Elliott et al (2010), and Rauch et al (2010).

1. COSTS TO CONSUMERS

Since the cap-and-trade policy raises the consumer's price of electricity to P^g, it reduces consumer surplus by the trapezoid area A+D. The amount of this price increase and the resulting burden depend on various considerations that need to be analyzed. It is relatively large, as drawn, because the negative elasticity of demand (η^D) has smaller absolute value than the elasticity of supply (η^S).[4] Thus economic analysis in each case needs both a demand and supply elasticity, and data on the fraction of each group's income spent on the good. For example, climate policy would raise the price of gasoline, for which West and Williams (2004) estimate a set of demand parameters. They calculate four different measures of consumer surplus (area A+D) for each income group, and they find that the increase in gasoline price is regressive.[5] In some analyses it is not strictly regressive, because the very poorest households cannot afford a car (Poterba, 1991).

The effects of climate policy on multiple output prices are calculated in CGE models by Elliott et al (2010) and by Rausch et al (2010), but a simpler analytical general equilibrium model of Fullerton and Heutel (2010) aggregates carbon-intensive goods and finds that an increase in the CO_2 price from \$15/ton to \$30/ton would raise that output price by 7.2%. They then use data on spending and incomes of thousands of households in the Consumer Expenditure Survey (CEX) to find that the ratio of burden to income rises monotonically across annual income deciles. The first eight deciles lose more than average, while the highest two income deciles lose less than average.

In analyzing distributional effects, a major issue is how to define who is rich or poor. A problem is that the lowest annual income group includes some whose income is temporarily low and others who are stuck at that level. An alternative is to classify households by their total annual consumption expenditures, because it is a proxy for permanent income (assuming people smooth their consumption by spending less than their annual income in good years and more in bad years). When households in the CEX are classified by annual consumption, climate policy is less regressive.

[4] The permit price ($P^g – P^n$) is analogous to a tax wedge. Fullerton and Metcalf (2002) show that the fraction of a tax borne by consumers is $\eta^S/(\eta^S – \eta^D)$. This fraction is higher with a larger η^S or smaller η^D.

[5] One measure assumes no price responses, one assumes all groups have the same price response, ones uses each group's own price response, and the fourth is the equivalent variation for each group. The higher gas price is most regressive with no return of revenue, less regressive when revenue is used to cut wage taxes, and becomes progressive when revenue is used to provide the same lump-sum rebate to each household.

Finally, of course, distributional effects could be measured not just across income groups, but across regions, age groups, or demographic characteristics. Climate policy would disproportionately burden Southern states in the U.S., where people spend more than average on electricity to run their air conditioners. And, of course, higher fuel and electricity costs would hurt current generations more than future generations who would benefit from technological progress that reduces the cost of renewable fuels and energy-efficient appliances. Distributional effects also could be measured across countries. For the same carbon price, nations that rely disproportionately on coal would face higher electricity prices than those who use less-carbon-intensive fuel like natural gas. Denmark uses a lot of wind power, while Sweden uses hydroelectric power.

2. COSTS TO PRODUCERS OR FACTORS

Energy or environmental policy may also impose burdens on producers or factors of production. In Figure 1, the loss in producer surplus is area B+E. This area is small, as drawn, because the supply curve (PMC) is relatively elastic. These losses are larger if instead production involves industry-specific resources in relatively fixed supply, such as a specific type of energy, land with specific characteristics, or labor with particular skills. If so, then the cut-back in production burdens the owners of those limited resources.

Again, CGE models like those of Elliott et al (2010) or Rausch et al (2010) can be used to compute a new economy-wide wage, rate of return, or land rent. Sophisticated dynamic general equilibrium models could be used to solve for short run effects, capital deepening, and the transition to a new balanced growth path with a new labor/capital ratio. The analytical general equilibrium model of Fullerton and Heutel (2010) is not a growth model, since labor and capital are both in fixed supply, but it can show intuitively the effect of a carbon tax on multiple output prices and factor prices – including the wage for labor and the return to capital. The "clean" sector uses only labor and capital, but the "dirty" sector uses labor, capital, and pollution. With three inputs, any two can be complements or substitutes. The "substitution effect" places less burden on whichever factor is a better substitute for pollution (and more burden on the other one). Because the carbon policy raises output price and reduces production, the "output effect" is likely to place more burden on whichever factor is intensively used in the dirty sector.[6] Rausch et al (2010) also consider other sources of income such as from natural resources and from

[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.

existing U.S. transfer programs. Government transfers are often indexed to inflation, so an increase in energy prices leads to automatic cost-of-living adjustments. This aspect of existing policy makes carbon pricing less regressive or even progressive.

3. BENEFITS OF SCARCITY RENTS

Any restriction on the quantity of the polluting good in Figure 1 makes the good scarce and gives rise to scarcity rents (area A+B). If the policy is a carbon tax or auction of permits, then government captures the scarcity rents as revenue. If it is a handout of permits or a simple quota, then area A+B becomes profits to the firms that are allowed to produce and sell the restricted quantity. Normally firms *want* to restrict output but are prevented by antitrust policy. Yet here, climate policy *requires* firms to restrict output. It allows firms to raise price, and so they make profits. That simple theory may be obvious in the case of Figure 1, where pollution is a fixed ratio to output, because a restriction on pollution also restricts output. But what if firms can abate pollution per unit of output?

Policy can still generate profits when firms can vary pollution itself, as shown by Maloney and McCormick (1982). They provide evidence for two different regulations, using data on stock market returns around the imposition of each regulation. First, the Occupational Safety and Health Administration imposed new cotton-dust technology standards uniformly on all textile firms in 1974. They look at a portfolio of 14 textile stocks, and they find a significantly positive abnormal return when this rule is imposed. Also, in 1973, the U.S. Supreme Court ruled in favor of environmental groups that sued the EPA to "prevent significant deterioration" of air quality in areas already complying with national standards. The new stricter standard only affected new entrants such as nonferrous ore smelting plants that emit sulfur oxides and particulates, so the authors consider stock prices of existing copper, lead, and zinc smelters. Significant positive abnormal returns were found for existing firms in those industries.

One might normally think that firms would oppose costly new environmental regulations, but Maloney and McCormick show that "the interests of environmentalists and producers may coincide against the welfare of consumers" (pp. 99-100). This point is key both for the politics of environmental legislation and for distributional effects.

In the case of climate policy, high abatement costs must be borne by somebody in society, but Parry (2004) shows how grandfathered permits generate profits that accrue to shareholders. Thus, this policy can benefit high-income groups while imposing costs on others. His analytical model has explicit formulas that show the impacts of underlying parameters, but the profits in his model are essentially area A+B. Figure 1 also shows how consumers pay a higher price for goods like electricity. For this reason, the House Bill would dedicate some permit value to reducing electric bills.

4. BENEFITS OF PROTECTION

The gain from environmental protection in Figure 1 is area C+D+E, the sum of "marginal external costs" over the range that emissions are reduced (from Q^o to Q'). What groups receive these benefits? Those who benefit from climate policy are exactly those who would otherwise bear the costs of global warming, including lost biodiversity, sea level rise, and extreme weather events like droughts, floods, and hurricanes. Cap-and-trade may thus provide benefits to those who enjoy wildlife, but also to drug companies that use biodiversity to develop new medications. It would benefit those who own coastal property. This carbon policy might also reduce emissions of local pollutants, and thus reduce morbidity and mortality.[7] No study provides a comprehensive measure of these distributional effects by income group.

Many of the effects are regional. Global warming might help those in cold areas, while imposing more costs on those in warm climates, dry climates, and low-lying areas subject to hurricanes or floods. For just one example, Daniel et al (2009) summarize 117 estimates from 19 U.S. hedonic house price studies of the effect of flood risk on house values, controlling for other differences in house and neighborhood characteristics.[8] They conduct a "meta-analysis" to summarize those studies, finding that a 0.01 increase in the probability of flood each year reduces house value by 0.6%, all else equal. Owners in low-lying areas benefit if climate policy prevents increases in flood probabilities.

Climate policy would reduce burning of fossil fuel and thus affect local pollutants and health, but it may also affect deaths from extreme hot or cold. Deschênes and Greenstone (2007) use annual temperature variation in two climate models to find that climate change will increase U.S. mortality by a small amount that is not statistically

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[7] The U.S. EPA (1999) finds that most benefits of the Clean Air Act are mortality reductions. Older or less healthy individuals have higher baseline mortality risk, and thus might benefit more from a reduction in the risk of dying this year. If so, climate policy benefits the elderly and infirm. On the other hand, they may have fewer years to live and be willing to pay less for a reduction in the risk of dying this year.

[8] With data on many house sales, the price can be estimated as a hedonic function of house characteristics and neighborhood 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 environmental improvement.

significant, but it would raise infant mortality more significantly. To offset some of those effects, people will increase residential air conditioning and thus energy use by 15-30%, and they may move location to avoid hotter temperatures. Thus, climate policy may reduce all these costs on those who now live in hotter climates.

These studies are mere examples of possible effects on different U.S. groups from climate change. A GHG policy would mitigate these effects within the U.S. as well as other distributional effects between countries. Mendelsohn et al (2006) use predicted climate changes across the globe to calculate each country's gain or loss. Currently, agricultural productivity is highest in temperate regions, and so countries in hot climates tend to be poor already. Thus, even the same increase in temperature would reduce productivity in poor countries more than in rich countries. In this sense, climate policy to reduce global warming may provide the most benefit to the poorest countries.

5. COSTS OF TRANSITION

Other distributional effects of climate policy include the costs of adjustment and transition. These costs may be large, even if temporary. In Figure 1, area E+F is the value of capital and labor leaving the industry. With perfect mobility, they immediately earn the same return elsewhere. With imperfect mobility, however, a policy shift can make existing plants obsolete and impose capital adjustment costs. It can disrupt labor markets as well, and impose costs of retraining, relocation, and possibly long spells of unemployment between jobs.

Few have studied labor adjustment costs, especially from climate policy. In one exception, Deschênes (2010) looks at the effect of energy costs on labor demand. He finds a negative cross-price elasticity. Since the cap-and-trade bill that passed the U.S. House of Representatives in 2009 would raise electricity prices by about 4%, his preferred estimate suggests that U.S. employment would fall by 460,000 (about 0.6%).

That estimate captures the effects on industries that react to their own higher electricity costs by reducing employment. It does not capture other effects. Climate policy does not operate through electricity prices, for example, if it reduces employment in mining or logging. These occupations constitute major sources of income for entire towns in some areas. Those workers may have acquired industry-specific human capital, and they lose that investment when the industry shrinks. At the same time, the new policy may increase employment in abatement technology, renewable fuel production, and reforestation. In other words, some lose from climate policy and others gain.

6. EFFECTS ON ASSET PRICES

Those five types of gains or losses are measured annually, in Figure 1, but they also can be capitalized into asset prices. For example, a corporate stock price might rise immediately from the expected future annual flow of scarcity rents (area A+B). Also, the current price of agricultural land can rise to reflect future benefits from reduced global warming, and the price of oceanfront property can reflect benefits of reduced sea level rise (areas C+D+E). If a policy to reduce carbon dioxide also reduces other emissions, then it likely provides different air quality improvements to different neighborhoods. If so, then the present value of those gains can be captured by certain homeowners at the time of the change.[9] The homeowner may then sell the house at a premium to someone else. If so, then the person who breathes the cleaner air is not the person who benefits from the environmental improvement. When assets change hands, capitalization effects make it particularly difficult to measure the distributional effects of climate policy.

Sieg, et al (2004) use data from 1989-91 in Southern California to estimate parameters of a structural model, and they use those estimates to calculate the welfare effects of air quality improvements from 1990 to 1995 (when ozone levels in different neighborhoods fell from 3% to 33%). Areas with the most improvement might see upward pressure on house prices, but then some households sell at a gain and move to other cheaper neighborhoods. These shifts induce further house price changes, until all prices achieve a new general equilibrium. In one location where ozone fell by 24% in their study, they found that house prices rise nearly 11%. Moreover, landlords reap gains while renters may lose. Areas with the most environmental improvement may see the most increase in rents, which forces out low-income renters.

Climate policy may cause major cutbacks in particular industries such as logging, mining, and coal-fired electricity generation. Corporate stock prices may fall by a large amount, but those losses in certain industries are not necessarily a major problem to any one person if investors diversify their portfolios. But workers may devote years of

[9] The asset price increase exactly equals the present value of future benefits only if markets clear with perfect information and no transaction costs. With major moving costs, however, the allocation of houses to owners may not perfectly reflect their willingness to pay. Also, the capitalization is moderated by any elasticity in the supply of land. The price may rise less if fringe land can be converted to residential use.

training and learning on the job in such an industry, and then become unable to find any work in that industry after cut-backs. If so, the burden is not just the lost wage in a given year, but the entire present discounted value of lost wages in all future years. This human capital investment is not diversifiable, and so it can impose a much larger percentage loss for certain individuals than other asset price capitalization effects of climate policy.

7. CONCLUSION

Prior literature emphasizes the economic efficiency effects of environmental policy, but economists are now beginning to study distributional effects that can be much more difficult and challenging. This paper illustrates the many types of distributional effects that can arise from just one new climate policy, and it thereby makes clear why no single study could possibly incorporate all of them. Initial studies have looked at output price and factor price changes, and generally find the impact to be regressive. If the permits are sold at auction, then revenue is available to rebate to low-income households and offset those regressive effects. But only careful analysis of all six effects can ensure improvements in environmental protection without adverse distributional consequences.

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