Distributional Considerations in Climate Change Mitigation:
Policy Design as if the Present Generation Matters

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Abstract

The case for climate policy typically is made on grounds of inter-generational equity, with a presumed tradeoff between the environmental interests of future generations and the economic interests of the present generation. This framing of the problem neglects the scope for designing effective climate policies that yield net benefits for all or most people who are alive today. This paper considers two ways in which climate policy can bring substantial immediate gains, via (i) the air quality co-benefits from reduced use of fossil fuels; and (ii) the recycling of rent created by carbon pricing. Both pose important issues of distributional equity within the present generation.

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1. Introduction

In climate policy debates, the question typically is framed as a tradeoff between the welfare of the present generation and that of future generations. Policies to mitigate climate change – most importantly, by reducing carbon dioxide emissions from the use of fossil fuels – will require sacrifices on the part of those alive today for the sake of their children, grandchildren and the generations who will follow them.

This framing of the issue, reminiscent of jeremiadic sermons on wickedness, doom, repentance and redemption, appears to resonate with many elite environmentalists. But its appeal to broader populations – whose support is necessary to enact and sustain effective climate policies – is open to doubt. Moreover, it plays into the "economy versus environment" narrative so often deployed by opponents of environmental protection.

Yet it is possible to design climate policies that bring immediate, short-term benefits to people alive today. These go beyond the millions of jobs that can be created through investments in the energy efficiency and renewable energy,[1] important as these are, to include benefits to the vast majority of the public as a whole. This paper two such benefits: the air quality "co-benefits" from reduced use of fossil fuels, and egalitarian recycling of rent created by pricing carbon emissions.

Economic analysis of climate policy has featured often contentious debates on *inter-generational* equity, focused on the choice of an appropriate discount rate for use in integrated assessment models. The Stern review, for example, advocated a discount rate of about 1.4%, while Nordhaus has advocated rates of 4% or higher.[2] In part, the logic for using a higher rate hinges on predictions as to the average incomes of future generations. Citing the Stern review's assumption that global per capita income will rise from $10,000 today to around $130,000 (in today's dollars) in two centuries, Nordhaus (2008) remarks, "While there are plausible reasons to act quickly on climate change, the need to redistribute income to a wealthy future does not seem to be one of them."

If climate policy can bring substantial net benefits to present as well as future generations, the choice of discount rate becomes less important. Instead important *intra-generational* equity issues come to the fore. This paper considers these distributional issues in the case of air quality co-benefits and carbon rent allocation.

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[1] On employment creation potential of "green growth," see Pollin et al. 2014 on the United States; and Pollin et al. 2015 on Brazil, Germany, Indonesia, South Africa and the Republic of Korea.

[2] Stern 2007; Nordhaus 2007. For a review, see Goulder and Williams 2012.

2. Air Quality Co-Benefits

In addition to lower carbon dioxide emissions, policies that reduce fossil fuel combustion yield substantial air quality co-benefits via reduced emissions of "co-pollutants" such as particulate matter, sulfur dioxide, nitrogen oxides, carbon monoxide and other toxic chemicals. Indeed, exercises that assign monetary values to damages from carbon emissions and from co-pollutant emissions often have put higher values on the latter. Because co-pollutant intensity (the ratio of co-pollutant impacts to carbon emissions) varies across pollution sources, attention to the distribution of air quality co-benefits of carbon emissions reductions in climate policy design is important from the standpoints of both efficiency and equity.

Magnitude of air quality co-benefits

The World Health Organization (2014) characterizes air pollution as "the world's largest single environmental health risk," reporting that it is responsible today for one in eight deaths worldwide. Noting that air pollution is often a by-product of unsustainable policies in transport, energy and other sectors, the WHO observes that in most cases, more sustainable policies "will be more economical in the long term due to health-care cost savings as well as climate gains."

A number of studies have placed monetary valuations on the air quality co-benefits that could be obtained from reduced combustion of fossil fuels. The U.S. National Academy of Sciences (2009) has calculated that premature deaths attributable to co-pollutant emissions from fossil fuel combustion impose a cost of $120 billion/year in the United States. A study of the health co-benefits of carbon emissions reductions in the European Union for the Netherlands Environmental Assessment Agency concluded that co-benefits of a stringent climate policy would offset the policy's costs "even when the long-term benefits of avoided climate impacts are not taken into account" (Berk et al. 2006). Summarizing 37 studies of air quality co-benefits from around the world, Nemet et al. (2010) found a mean co-benefit of $49 per ton of CO_2. A recent IMF study (Parry et al. 2014) of domestic co-benefits of carbon pricing in the top twenty CO_2 emitting countries similarly concluded that, without counting global climate benefits, the nationally efficient price averages $57.5 per ton of CO_2, above the global damage of $35/ton estimated by U.S. government's Interagency Working Group on the Social Cost of Carbon (2013).

The salience of public health co-benefits for climate policy design may be even greater than these valuation studies suggest. In a recent study of the "social cost of atmospheric release" that estimates the health costs as well as climate costs of multiple pollutants, Shindell (2015) notes "the reality that near-term health impacts seem to typically be considered more important to citizens than longer-term impacts of any sort, consistent with the vastly greater sums spent on medical care and research than on long-term environmental protection."

Efficiency and equity implications of air quality co-benefits

What do these findings imply for climate policies? From the standpoint of efficiency, two conclusions follow. First, the air quality co-benefits of emissions reduction warrant more stringent regulatory interventions (for example, higher carbon prices) than if policy were based on CO_2 emissions alone. Second, insofar as co-benefits vary across sources, efficiency requires more emissions reductions where the co-benefits are greater.

To illustrate the rationale for taking into account differences in abatement benefits across emission sources, consider two facilities in California: a power plant located outside Bakersfield, and a petroleum refinery located in metropolitan Los Angeles. Each emits roughly 3 million tons per year (t/yr) of carbon dioxide. The power plant emits about 50 t/yr of particulate matter (PM) and has fewer than 600 residents living in a 6-mile radius. The refinery emits about 350 t/yr of PM with about 800,000 residents living within a 6-mile radius (Pastor et al. 2013). Clearly, the population health co-benefits associated with emission reductions are likely to be much greater in the case of the latter facility.

This is a dramatic example, but it is not unique. In an analysis of variations in co-pollutant intensity for industrial point sources in the United States, Boyce and Pastor (2013) found substantial differences across industrial sectors. For example, emissions of PM2.5 (fine particulates with a diameter of 2.5 micrometers or less) per ton of CO_2, weighted by the population living within a 2.5-mile radius of the facility, are on average more than six times higher than those from power plants (see Table 1).

Table 1: PM2.5 intensity by industrial sector, United States

Industrial sector	**Population-weighted PM2.5 per ton CO2**	**Minority share** (%)
Primary metal manufacturers	19.7	47.5
Non-metallic mineral product manufacturers	8.6	39.8
Petroleum refineries	8.4	59.5
Chemical manufacturers	5.2	43.9
Power plants	3.0	38.8

Source: Boyce and Pastor 2013.

Air quality co-benefits matter from the standpoint of distributional equity, too. In the United States, for example, a substantial body of literature has found that racial and ethnic minorities and low-income communities tend to bear disproportionate pollution burdens (see, for example, Ringquist 2005; Mohai 2008; Morello-Frosch et al. 2011; Zwickl et al. 2014). Again, the extent of disparities differs across industrial sectors and locations. Boyce and Pastor (2013) find that minorities bear 59.5% of the impact of population-weighted PM2.5 from petroleum refineries in the United States, compared to 38.8% of the impact from power plants and to their 34.2% share in the national population.

These findings suggest that any climate policy that fails to incorporate air-quality co-benefits into its design will not be inefficient by virtue of forgone public health benefits, but also inequitable by virtue of foregone opportunities to redress air quality disparities. In the U.S., Executive Order 12898, “Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations,” issued by President Clinton in 1994, explicitly mandates that all federal agencies should seek to identify and address the disproportionately high and adverse human health or environmental effects of their actions on minority and low-income populations, a policy objective most recently articulated by the U.S. Environmental Protection Agency’s “Plan EJ 2014.”[3]

Options for incorporating air quality co-benefits into climate policy

Two broad types of policy instruments have been proposed to curb carbon emissions from fossil-fuel combustion: quantitative regulations, such as fuel economy standards and mandated technologies; and price-based policies, such as a carbon tax or marketed permits. These are not mutually exclusive, as policies can, and often do, combine both.

An attractive feature of price-based policies is that they provide incentives not only to use available emissions-reducing technologies, but also to invest in research and development of new technologies. Such policies have encountered opposition, however, from some environmental justice advocates on the grounds that they may allow co-pollutant “hot spots” to persist and possibly worsen in overburdened communities. Citing this concern, for example, environmental justice groups in California filed a lawsuit that attempted to block implementation of the state’s cap-and-trade program (Farber 2012).

Some economists maintain that co-pollutants are best regulated separately, and that they should not be taken into account in the design of climate policy (Schatzki and Stavins 2009). But unless we can safely assume that co-pollutant impacts are adequately addressed by other policies, efficient and equitable climate policy should take them into account – an approach consistent with growing interest in multi-pollutant strategies for air-quality management.[4]

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[3] See http://www.epa.gov/environmentaljustice/plan-ej/index.html.

[4] On multi-pollutant strategies, see National Academy of Sciences 2004 and McCarthy et al. 2010.

The administrative costs of incorporating air quality co-benefits into climate policy design could be modest, particularly where co-pollutant damages are concentrated in a small number of sectors or facilities, as in the case for industrial point sources in the United States (Boyce and Pastor 2013).

Policy options include the following:

1. *Monitor impacts on co-pollutants:* The minimalist option is to monitor co-pollutant emissions, with a view to adopting remedial measures if the climate policy has unacceptable impacts. This is the approach taken by the California Air Resources Board (2011) in its adaptive management plan for the state's cap-and-trade policy.

2. *Zonal tax or permit systems:* Zonal carbon permit or tax systems can ensure emissions reductions in high-priority locations where the potential public health benefits are greatest. Zone-specific caps were established, for example, in California's Regional Clean Air Incentives Market, which was initiated in 1994 to reduce point-source emissions of NO_x and SO_2 in the Los Angeles basin (Gangadharan 2004).

3. *Sectoral tax or permit systems:* Similarly, sector-specific tax or permit systems can be designed to ensure emissions reductions in those industrial sectors with the highest co-pollutant intensities and the most disproportionate impacts on minorities and low-income communities.

4. *Trading ratios:* In a tradable permit system where damages per unit of emissions vary across sources, the exchange rate at which permits are traded can be another policy instrument. For example, if total (CO_2 + co-pollutant) damages per ton CO_2 are twice as high in location or sector A as in location or sector B owing to higher co-pollutant damages in the former, the exchange rate (or "trading ratio") would be 1:2 (Muller and Mendelsohn 2009).

5. *Community benefit funds:* Some fraction of the revenue from carbon taxes or permit auctions (the "carbon rent" discussed in the next section of this paper) can be channeled into community benefit funds to mitigate co-pollutant impacts and protect public health in vulnerable communities. Such a policy has been enacted for revenues from permit auctions under the California's climate policy.

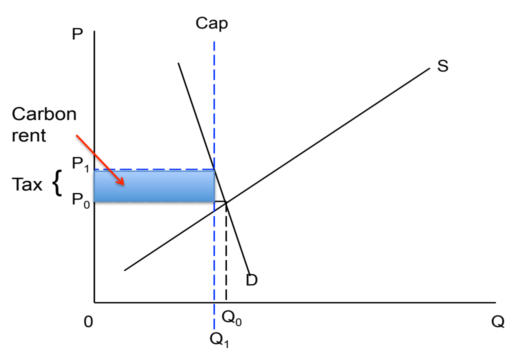
3. Carbon Rent Allocation

Putting a price on carbon emissions via a cap or tax is often regarded as a central element of climate policy, for good reason. Although regulatory instruments, such as renewable portfolio standards for electric power generation or low-carbon fuel standards for automobiles, are often part of the policy mix, too – as in California under that state's Global Warming Solutions Act – carbon pricing is useful both to achieve emissions reductions in the short run and to provide incentives for technological innovation in the long run. In addition, carbon pricing offers opportunities to build durable public support for climate policy, if the resulting revenue – here termed "carbon rent" – is allocated in a fair and transparent manner.

From the standpoint of administrative cost, a carbon cap or tax can be most efficiently implemented where fossil fuels enter the economy: at tanker terminals, pipeline hubs, coal mine heads. For each ton of carbon it brings into the economy, the fossil fuel firm must surrender a permit or pay a tax. The U.S. Congressional Budget Office (2001) has estimated that such an upstream system would involve about 2,000 collection points nationwide, far fewer compliance entities than would be the case in a downstream system.

The carbon rent created by a cap or tax on the use of fossil fuels is depicted in Figure 1. A cap reduces the quantity of fossil fuel from Q_0 to Q_1. A tax raises the price of fuel from P_0 to P_1. A cap sets the quantity of carbon emissions and lets the price adjust; a tax sets the price and lets the quantity adjust. Although the policy choice between a cap and a tax is often a subject of spirited debate, apart from this difference the two are equivalent. Carbon rent is the revenue created by this policy-induced scarcity in the supply of fossil fuels. Because the price elasticity of demand for fossil fuels is low – in economic terms, they are a necessity rather than a luxury – the percentage increase in price exceeds the percentage decrease in quantity. Hence the tighter the cap (or the higher the tax), the larger the carbon rent.

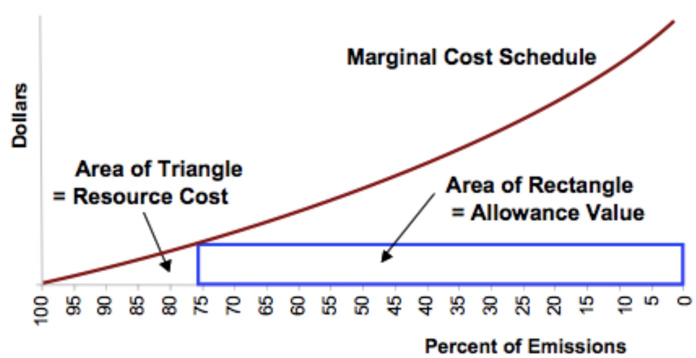
Figure 1: Carbon rent



Carbon rent is sometimes confused with the resource cost of reducing carbon emissions. Investments in energy efficiency or alternative energy require real resources. A number of studies have concluded that the resource costs of modest initial reductions in carbon emissions resulting from the introduction of carbon pricing will be low. In its analysis of the Waxman-Markey bill, the last attempt to enact federal carbon pricing legislation in the United States, the Congressional Budget Office (2009) estimated the resource cost in would amount to only 18 cents per household per day.[5] Indeed, some studies have concluded that substantial emissions reductions can be obtained at negative marginal cost – that is, the investments would pay for themselves at market interest rates (McKinsey & Co. 2007).

The difference between the resource cost of emissions reductions and carbon rent is depicted in Figure 2. The former is the cost of preventing emissions. The latter is the price paid for emissions that are not prevented; for this reason, it is often termed "allowance value" in discussions of cap-and-permit systems, in which allowances are a synonym for permits.

Figure 2: Resource cost versus allowance value (carbon rent)



Source: Burtraw et al. 2009.

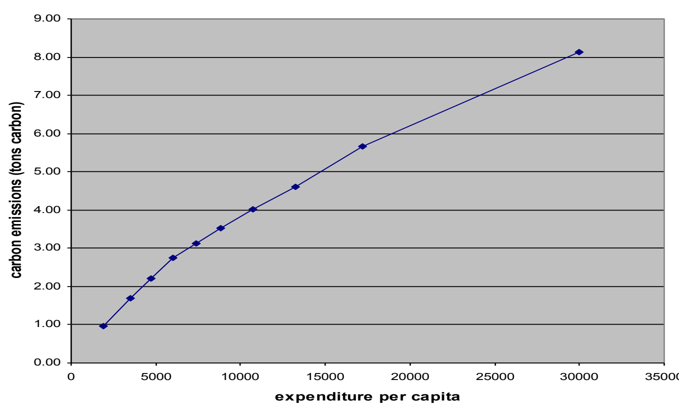
As Figure 2 suggests, the carbon rent generated by pricing policies is likely to exceed their resource cost by a considerable margin. In economic terms, carbon rent is not a cost; it is a *transfer*. The money is not spent on retrofitting buildings or installing solar panels; it is an extra amount paid for fossil fuel resources that would be produced even in the absence of the policy.

[5] The 18 cents/day figure comes from dividing the CBO estimate of "net annual economywide cost" of $22 billion/yr by the US population (335 million). In addition to resource costs for energy efficiency and alternative fuels, the CBO's $22 billion estimate includes costs for the purchase of international offsets and the production cost of domestic offsets (both of which would have been allowed under the bill) and overseas spending on adaptation and mitigation.

The tax or permit price is passed through to consumers either directly in the market prices of gasoline, heating fuels and electricity, or indirectly in the market prices of food, manufactured goods, and everything else that is produced or distributed using fossil fuels.[6] The extra money paid by consumers is the main source of carbon rent (as discussed below, some also comes from other final users of fossil fuels, notably government). Consumers pay in proportion to their direct and indirect consumption of fossil fuels, their "carbon footprints." Because upper-income households tend to have larger carbon footprints, in absolute terms, than other households, they pay more. As a percentage of household income and expenditure, however, low-income households in industrialized countries tend to pay more. In this respect, carbon pricing is a regressive tax.

The incidence of carbon pricing across households can be analyzed by combining consumer expenditure survey data with input-output tables that allow us to estimate the amount of fossil carbon embodied in different products. Figure 3 depicts the results of such calculations for U.S. households. Carbon rise with total household expenditure, as expected, but fall as a percentage of expenditure as indicated by the concave curve. Similar relationships have been found in other industrialized countries.[7]

Figure 3: Carbon emissions by expenditure class, United States



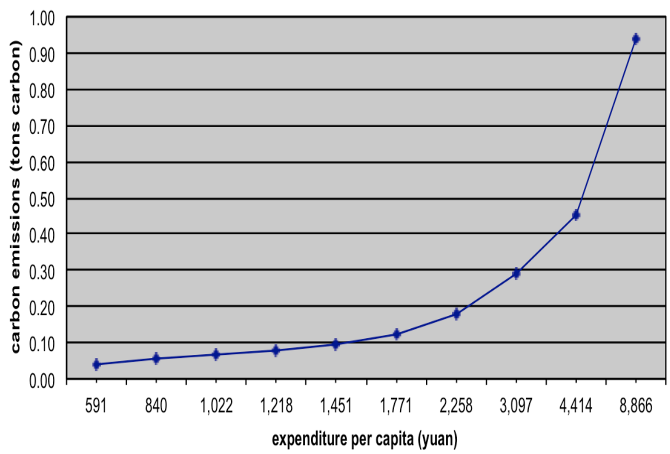
Source: Boyce and Riddle 2007.

[6] Most economic analyses assume that 100% of the carbon price is passed through to consumers. In practice, it is possible that "pass-through" would be a little less than 100% (or even a little more), if fossil fuel firms cut profit margins in an effort to protect their market shares (or use the policy as a pretext to increase profit margins). For discussion of the effects of the degree of pass-through on carbon rent, see Boyce and Riddle 2007.

[7] See, for example, Cramton and Kerr 1999; Symons et al. 2000; and Wier et al. 2005.

There have been fewer studies of the incidence of carbon pricing in low and middle-income countries, where low-income households may have smaller carbon footprints than upper-income households, even as a percentage of their total expenditure, by virtue of their very low levels of direct and indirect consumption of fossil fuels. Figure 4 depicts the relationship between carbon emissions and household expenditure in China in the year 1995. The convexity of the curve indicates that in China at that time, the incidence of carbon pricing would have been progressive.

Figure 4: Carbon emissions by expenditure class, China (1995)



Source: Based on data in Brenner, Riddle and Boyce 2007.

The net impact of carbon pricing policies on income distribution depends crucially, however, on to whom the carbon rent is transferred. Broadly speaking, there are three possibilities:

- *Cap-and-giveaway-and-trade policies* (usually simply termed "cap-and-trade") give carbon permits to firms free of charge, based on a formula that takes into account their historic emissions.[8] The European Union's Emissions Trading System (ETS) for power plants and industrial point sources is an example. The recipient firms receive windfall profits, much as OPEC profits by restricting oil supplies: when the supply of fossil fuels is reduced, prices go up, and suppliers get the money. In this option, the carbon rent ultimately flows to the shareholders and executives of the firms that get free permits. Because these tend to be upper-income households, the net distributional effect is regressive.

[8] Because the permits are given away to firms, rather than distributed via an auction, some may find it profitable to sell some of their permits to others who find it profitable to buy them. For this reason, trading is part of this policy.

- *Cap-and-spend policies* auction the permits, rather than giving them away for free, with the auction revenue going to the government. The total auction revenue is equal to the carbon rent, since what firms are willing to pay for permits is equal to what they recoup in higher prices from the buyers of fossil fuels. Government can use the revenue for public expenditures, tax cuts (or "tax expenditures"), or budget deficit reduction. The Regional Greenhouse Gas Initiative (RGGI) for power plants in the northeastern U.S. states is an example. A carbon tax in which the revenues flow to the government is an equivalent policy. The net distributional impact depends on how the government chooses to use the carbon revenue.

- *Cap-and-dividend policies* also auction the permits, but the revenue in this case is recycled to the public as equal per capita dividends rather than retained by the government. The underlying principle behind dividends is that the scarce carbon absorptive capacity of the biosphere (or more precisely, a nation's or state's share of it) belongs in common and equal measure to all its people, rather than to fossil fuel firms or to the government.[9] A carbon tax in which the revenues are returned to the people as lump-sum payments (sometimes called "fee-and-dividend") is an equivalent policy. The net distributional impact would be progressive, since as shown in Figures 3 and 4 high-income households pay more in absolute terms than low-income households as a result of higher fossil fuel prices, while all receive the same dividend payments.

The net effects of a cap-and-dividend policy for pricing carbon and allocating the carbon rent in the United States are shown in Table 2 under two policy scenarios. Both assume a carbon price of $25 per ton of CO_2. In the first scenario, 100% of the carbon rent is recycled directly to the public as equal per capita dividends. This is proposed in the climate policy bill that was introduced by Congressman Chris Van Hollen in July 2014 and reintroduced in February 2015.[10] In the second scenario, 75% of the carbon rent is recycled as dividends and 25% is retained for public investment. This was proposed in the climate policy bill that was introduced by Senators Maria Cantwell and Susan Collins in December 2009.[11]

[9] A similar principle is applied to royalties from petroleum extraction in the Alaska Permanent Fund, from which annual dividends are paid to all state residents (Barnes 2014).
[10] Text available at http://vanhollen.house.gov/sites/vanhollen.house.gov/files/VANHOL_011_xml.pdf.

[11] For details, see Boyce and Riddle 2011.

Table 2: Net incidence of cap-and-dividend policy for allocation of carbon rent, United States

Expenditure decile	Scenario 1: 100% as dividends	Scenario 2: 75% as dividends
1 (poorest)	289	190
2	253	154
3	225	126
4	201	102
5	175	76
6	148	49
7	117	18
8	77	-22
9	18	-81
10 (richest)	-109	-200

Source: Author's calculations; for methods, see Boyce and Riddle 2011.

As can be seen, the majority of households would receive positive net benefits from the policy: their dividends would exceed what they pay as a result of higher fossil fuel prices. This result holds not only at the national level but also in each of the 50 states, although the percentage of households that would come out ahead varies depending, in particular, on the carbon-intensity of the state's electricity supply (Boyce and Riddle 2009). There are two reasons for this result. First, because income is highly concentrated in the upper deciles, so, too, are carbon footprints: that is, the mean is above the median, and dividends are derived from the mean. Second, household consumption accounts only accounts for about 2/3 of fossil fuel use in the United States. The remainder comes from fossil fuel use by government, non-profit institutions, and the production of exports (Boyce and Riddle 2008).

Economists sometimes maintain that carbon rent allocation entails a tradeoff between equity and efficiency. While acknowledging that equal per capita dividends (that is, lump sum payments) would be more equitable than a revenue-neutral "green tax shift" in which carbon revenues are retained by the government and offset by cuts in income and/or sales taxes, they claim that the latter would be more efficient (Burtraw and Sekar 2014). The latter argument rests on the "double dividend hypothesis," which holds that such a tax shift not only reduces pollution (the first dividend) but also, by substituting for distortionary taxes that reduce the supply of labor and capital, can lead to higher output (the second dividend). The validity of this claim can be questioned on two grounds. First, as suggested by the relative income hypothesis, people may tend to work too much rather than too little (Wendner and Goulder 2008). Second, in real-world contexts of labor unemployment and capital underutilization, increases in the supply of labor and capital do not translate axiomatically into increased output.

Apart from its merits on grounds of equity, a compelling attraction of the cap-and-dividend option for allocation of carbon rent is that it could help to ensure durable public support for a policy that increases politically sensitive prices of transportation fuels and electricity. Getting an effective climate policy is not a one-shot game of enacting a piece of legislation. The policy must be able to endure over the several decades required for the clean energy transition, whatever political parties control the legislature and executive branches of government. It must be so popular among the voters that no party will be able to overturn the policy. It is difficult to imagine how such support can be maintained in the face of rising energy prices in the absence of the recycling of carbon rent to the public in ways that are highly transparent and perceived as fair.

4. Concluding remarks

Insofar as distributional considerations have entered into discussions of climate policy, these have often been posed as involving tradeoffs between the welfare of present and future generations. This paper has argued, however, that climate policy design raises important distributional considerations within the present generation, too.

Two central intra-generational issues in the distributional impacts of climate policy were explored here. The first involves the distribution of the air quality co-benefits that will accompany reductions in the use of fossil fuels. By some calculations, these are as large, or larger, than the climate benefits themselves. Because air quality co-benefits are local or regional, rather than global, and because co-benefits per ton of carbon reduction vary across space, industrial sectors and individual polluters, the ways in which they are (or are not) integrated into climate policy have important distributional implications. Because co-pollutant damages often tend to be greatest in low-income and politically disenfranchised communities, designing policy to seek greater emission reductions where the greater public health co-benefits will accrue can promote equity as well as efficiency.

The second distributional issue explored here involves the allocation of carbon rent. Climate policy is a form of property creation, in that it necessarily involves converting the carbon-absorptive capacity of the biosphere from an open-access resource (that is, a resource for which property rights are entirely absent) into resource governed by rights to control its use. When carbon pricing enters into the policy mix, either via a carbon cap-and-permit system or a carbon tax, another stick is added to the property rights bundle: the right to receive income from payments for use of the scarce resource. To date, the allocation of this income – here termed carbon rent – has not received a great deal of attention from economists, policymakers or the public at large. Yet here, too, important distributional issues arise, as illustrated by the choice among cap-and-trade, cap-and-spend and cap-and-dividend policies.

Indeed, if these distributional issues in climate policy design are addressed in an egalitarian fashion, based on the principles of equal rights to a clean and safe environment and equal rights to revenues from use of nature's gifts, the result can be positive net benefits – both in terms of health and income – for the majority of people in the present generation. If so, this will attenuate or eliminate the ostensible tradeoff in climate policy between present and future welfare, and in so doing remove one of the greatest obstacles to effective measures to safeguard the world's climate.

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